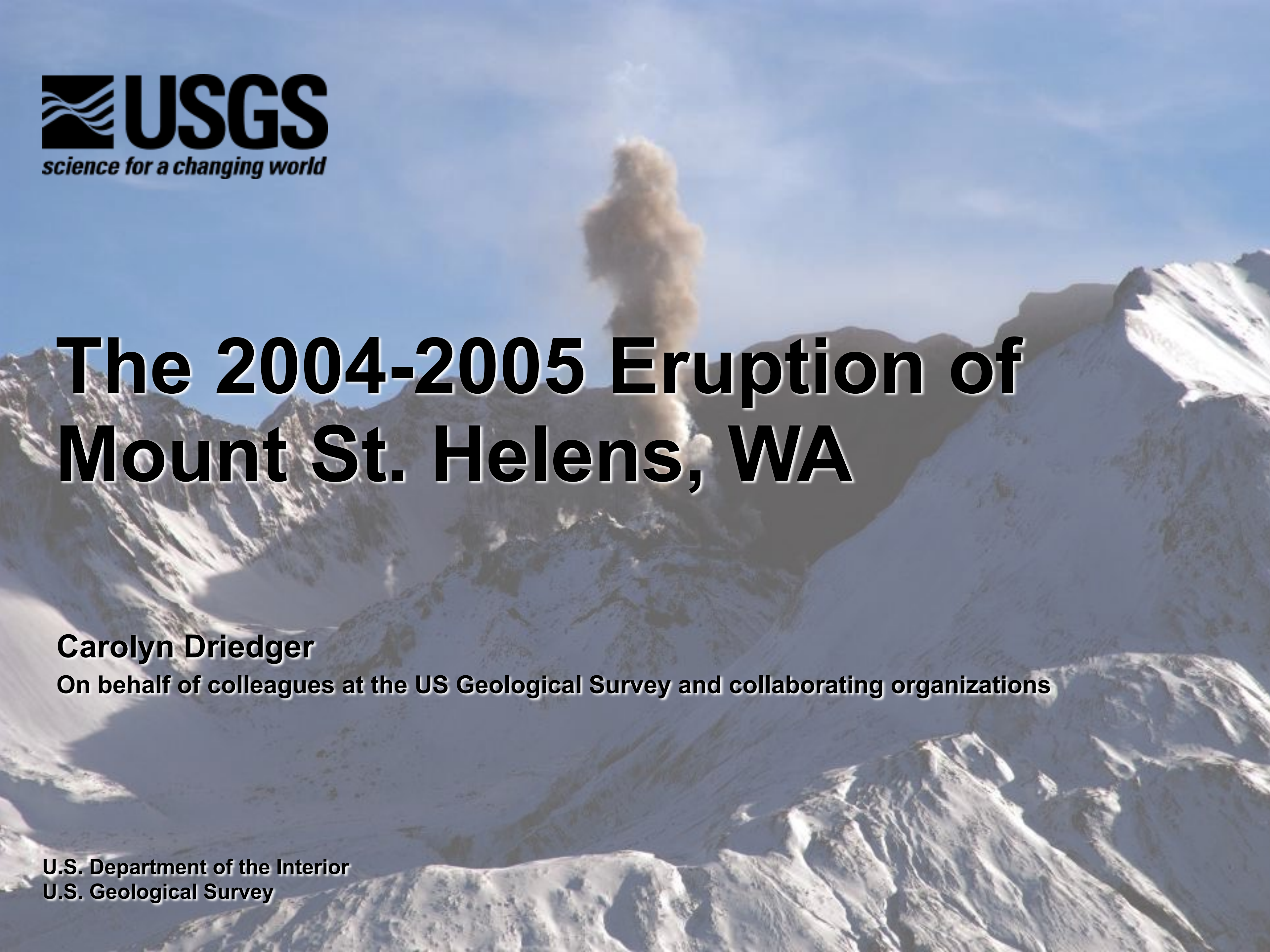


The 2004-2005 Eruption of Mount St. Helens, WA

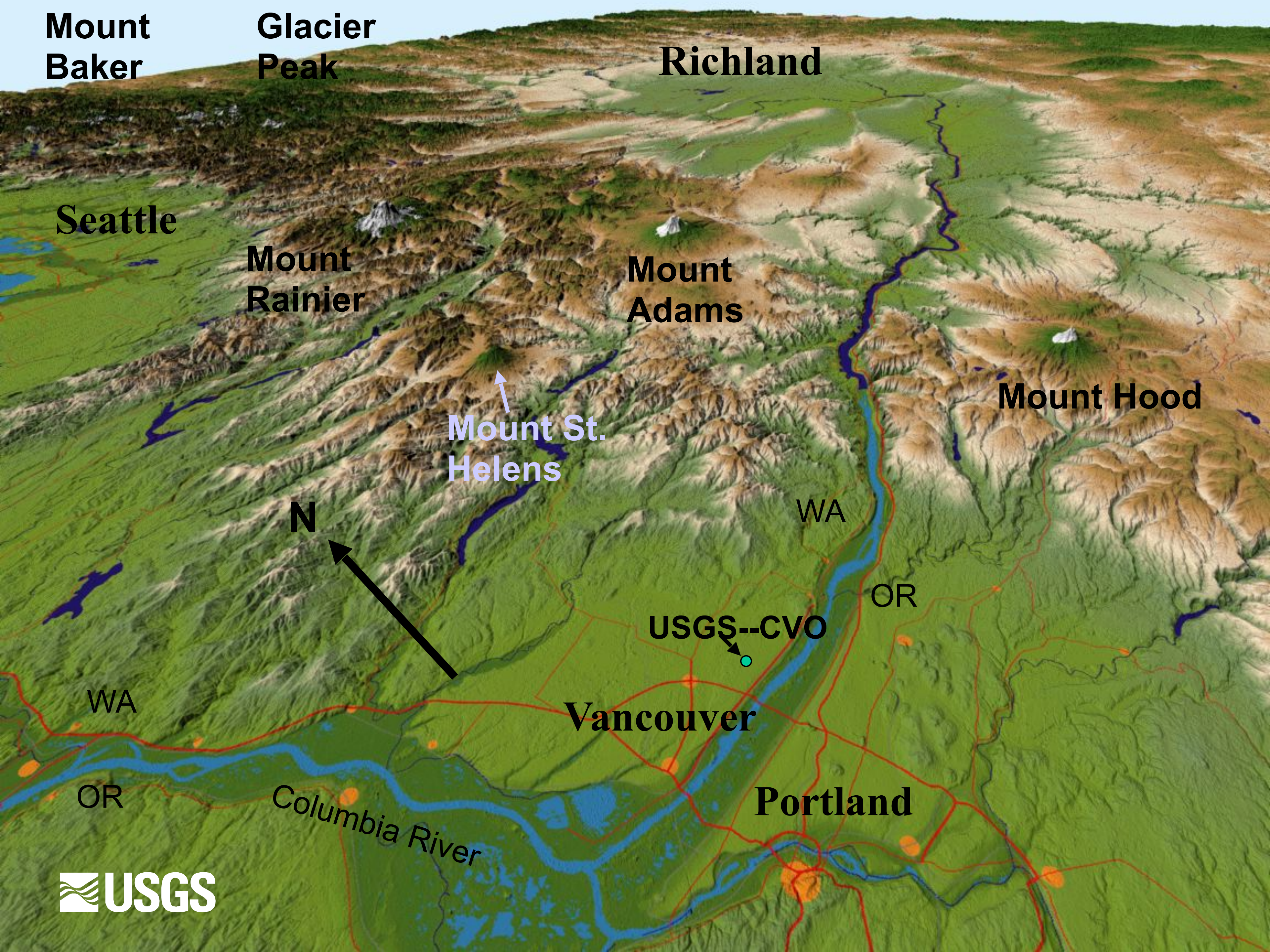
Carolyn Driedger

On behalf of colleagues at the US Geological Survey and collaborating organizations

U.S. Department of the Interior
U.S. Geological Survey

Acknowledgements

- Staff of CVO
- USGS visiting scientists
- Collaborators
  - PNSN at the University of Washington
  - Geological Survey of Canada, UBC
  - NASA
  - UNAVCO Plate Boundary Observatory
  - U Oregon, Oregon State U, PSU, WSU, U Iowa
  - Forest Service


Mount Baker
Glacier Peak
Richland
Seattle
Mount Rainier
Mount Adams
Mount Hood
Mount St. Helens
N
WA
OR
USGS--CVO
Vancouver
WA
OR
Columbia River
Portland
USGS

Eruption of Mount St. Helens in 1980 was a turning point for scientists, emergency managers and citizens of the Pacific Northwest

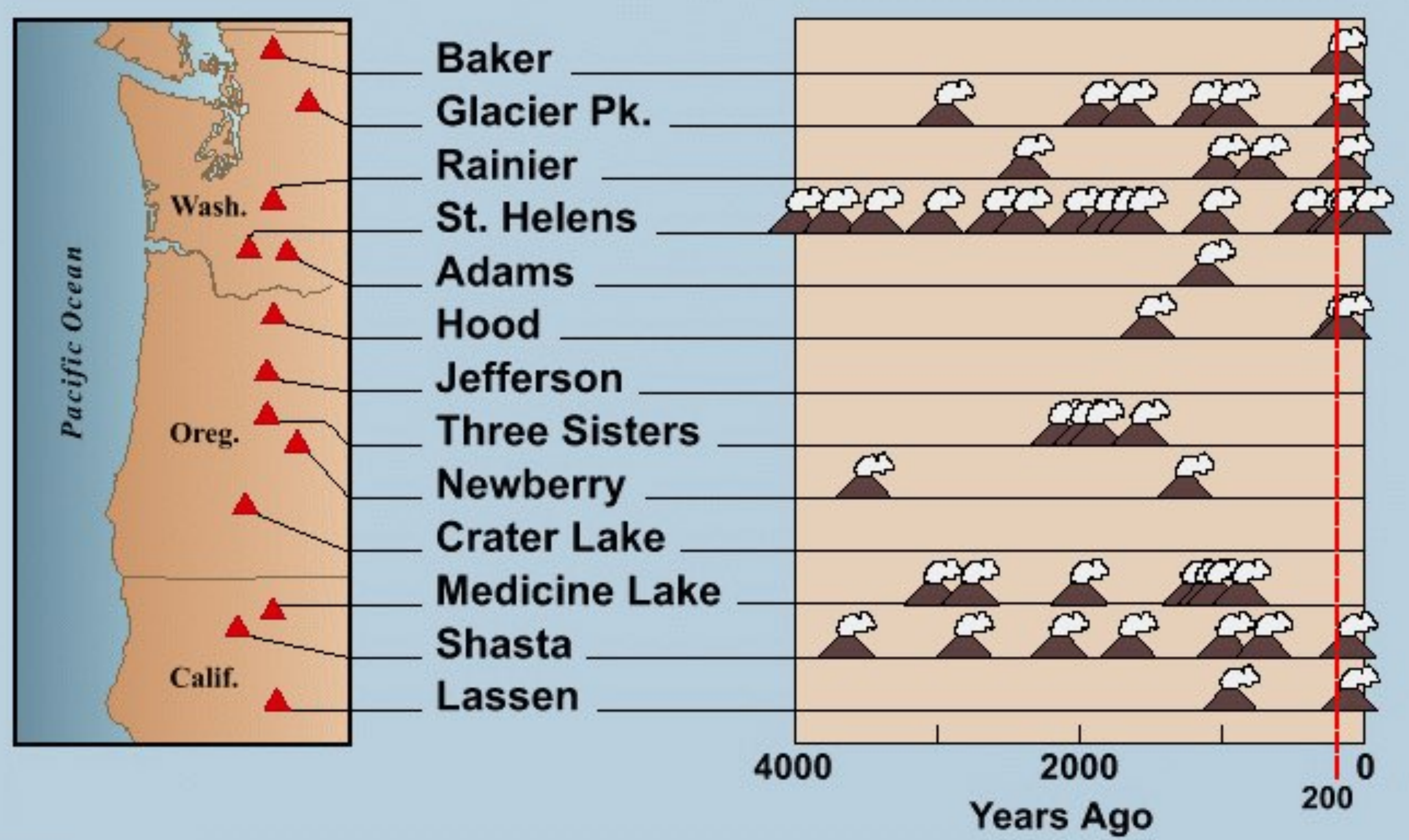
Six years of activity

Lateral blast killed 57 people, destroyed 4 billion board-feet of timber

Lahars destroyed 27 bridges, 200 homes, and 185 miles of roads

Ash covered 22,000 square miles

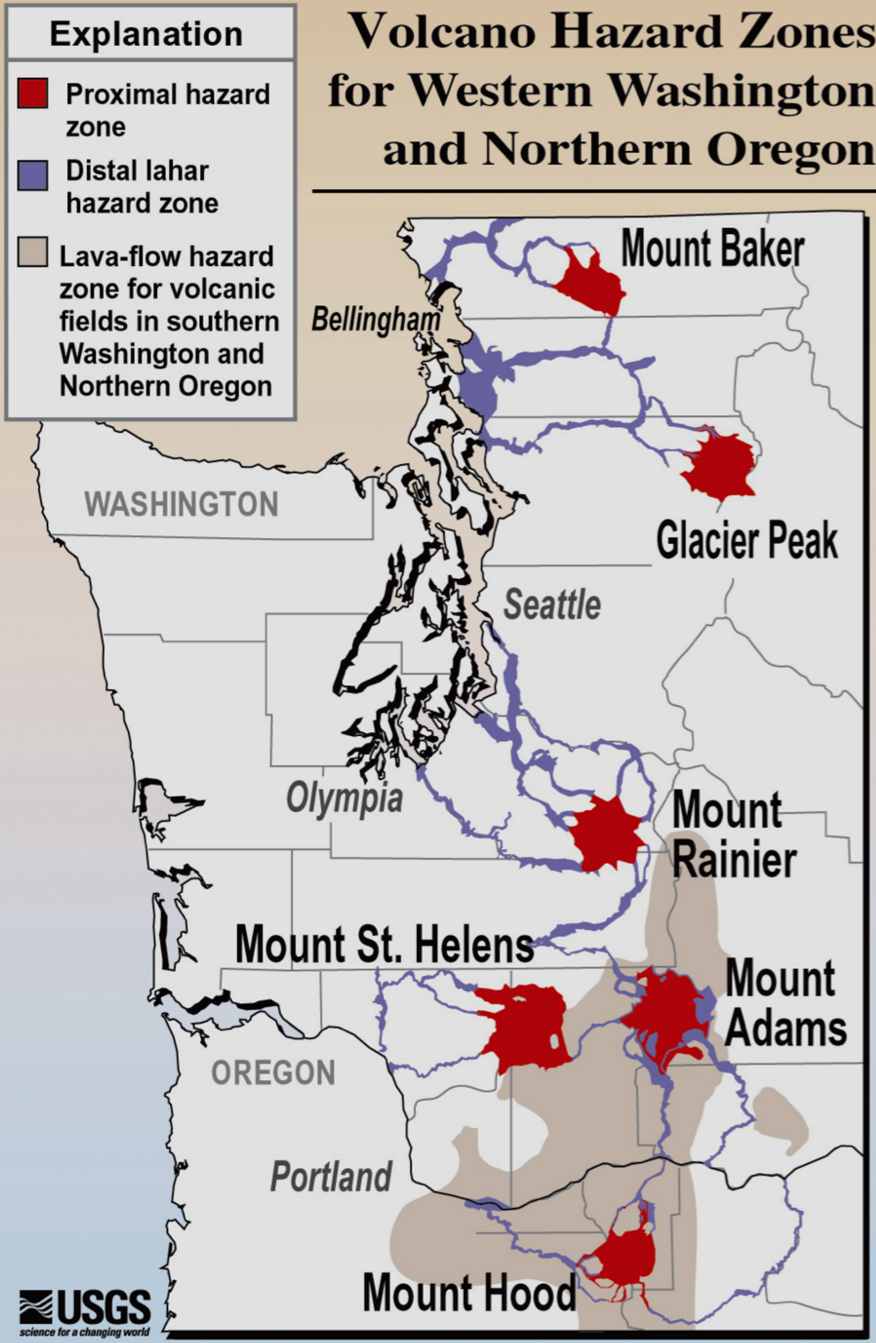
Cascade Eruptions During The Past 4,000 Years



USGS

Myers, USGS/CVO, 2000; Modified from: CVO, 1994, USGS Open-File Report 94-585

Volcano Hazard Zones for Western Washington and Northern Oregon



Mount Rainier

Mount St. Helens lahar, 1980

USGS David A. Johnston Cascades Volcano Observatory, Vancouver, WA

USGS Photo by Steve Schilling

1980 – 1986

USGS Photo by T.A.Leighley, October 24, 1980

2004 eruptions of Mount St. Helens– some firsts

- First eruption in the contiguous states since—
  - establishment of the Internet
  - 24-hour international news cycle
- First Webcam of viewable volcanic activity

USGS

Seismic and GPS stations around Mount St. Helens as of 27 October 2004

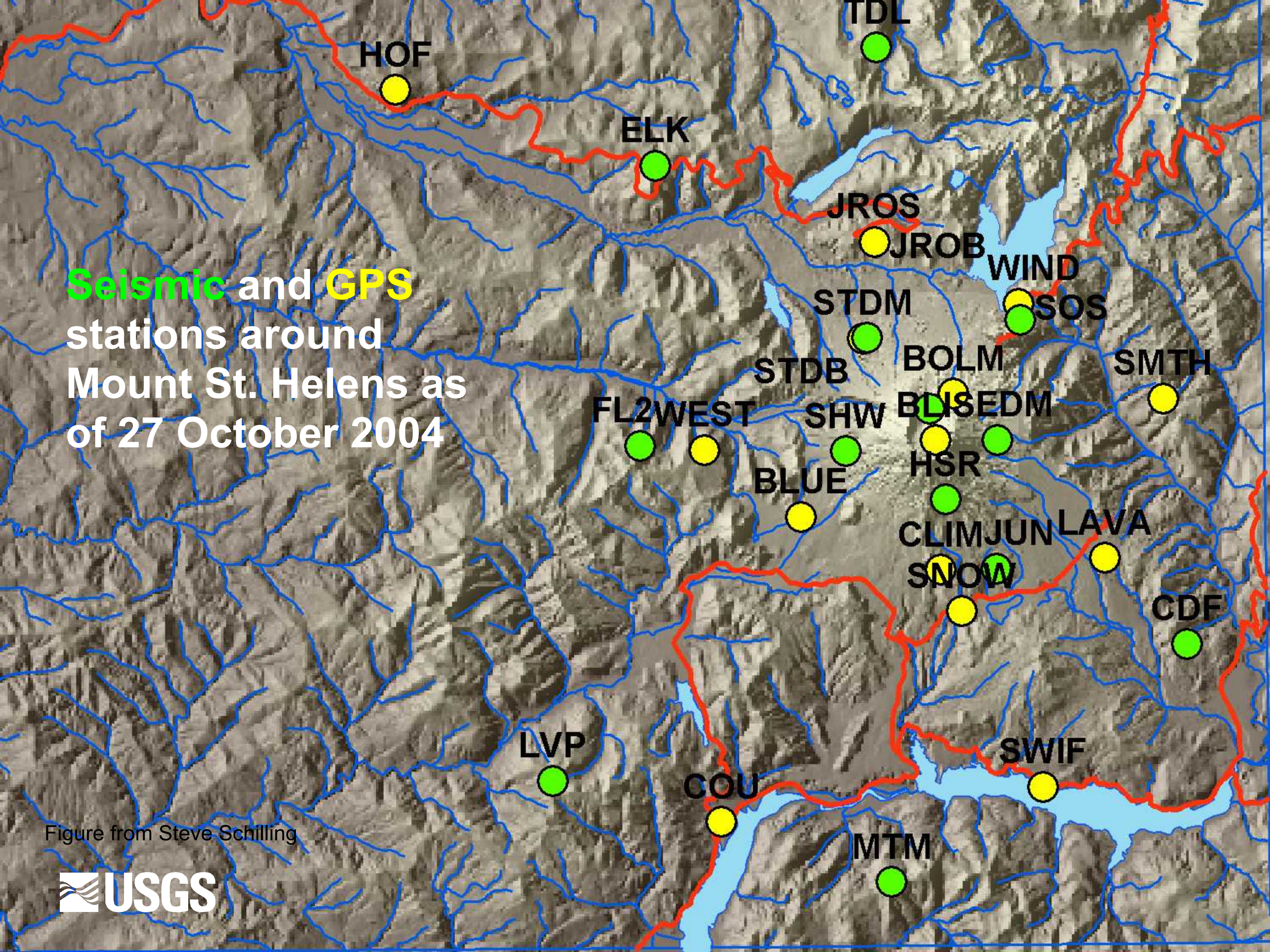
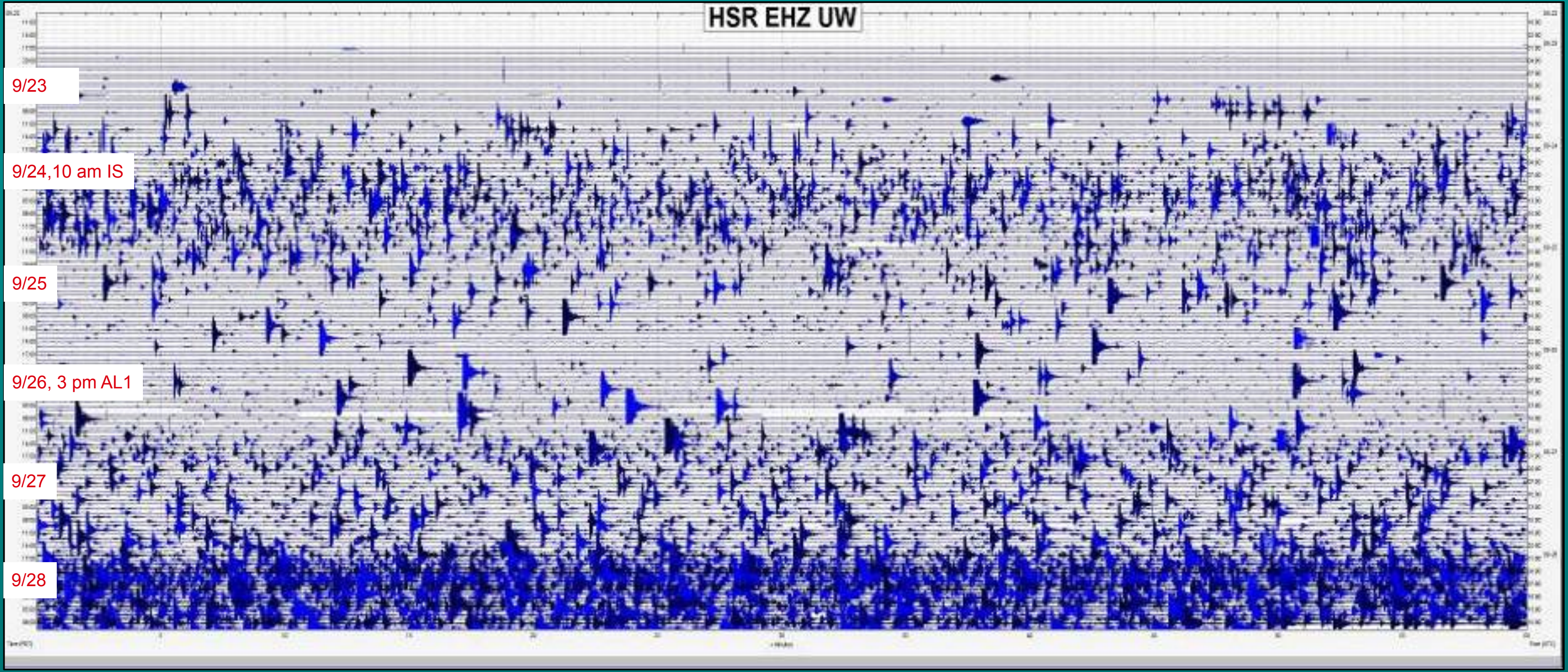
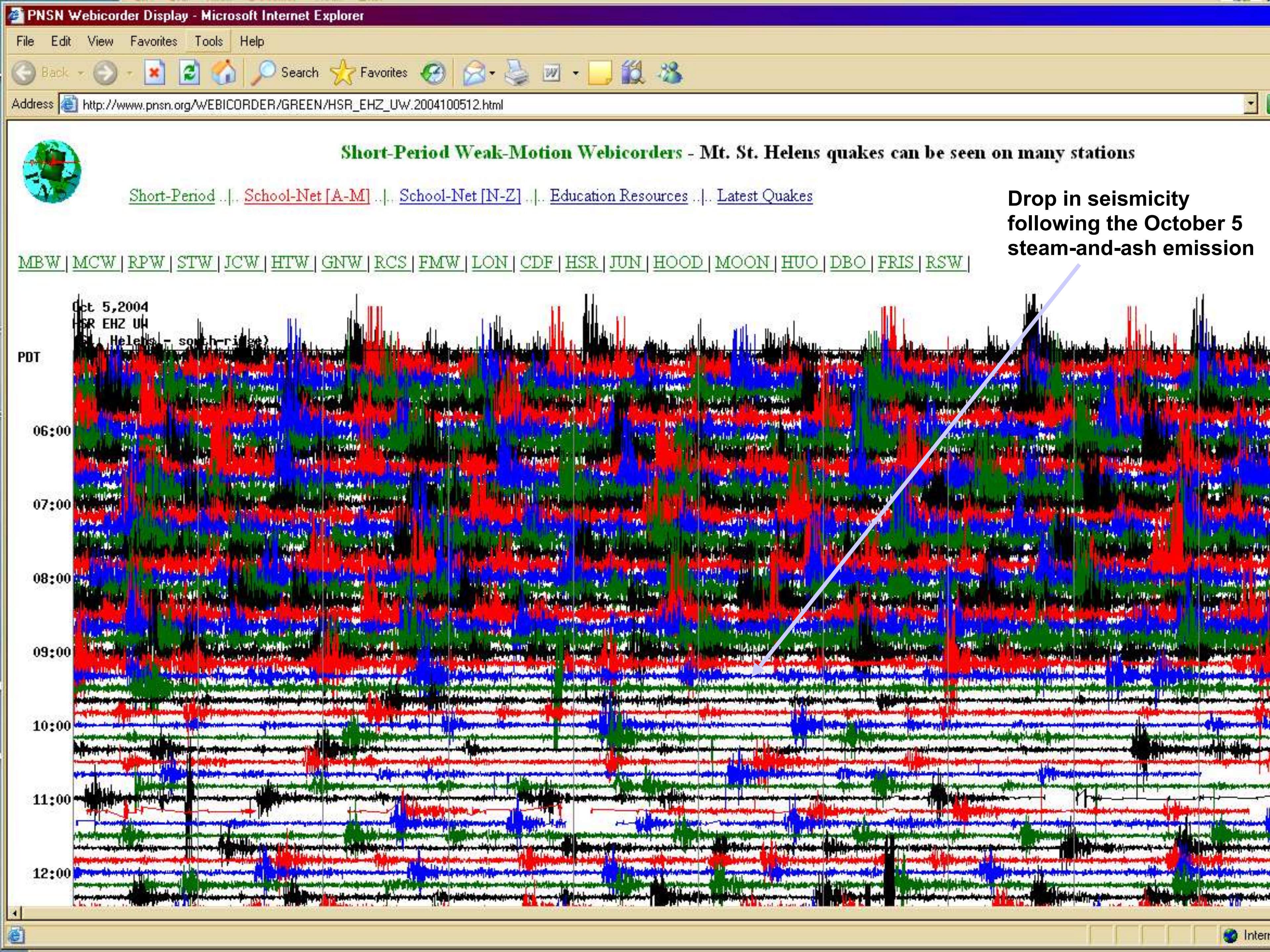


Figure from Steve Schilling

Early Seismicity



Small swarm starts Thursday, 9/23, wanes by Saturday, 9/25. Intensity picks back up on Sunday, 9/26 with average amplitude increasing with time.



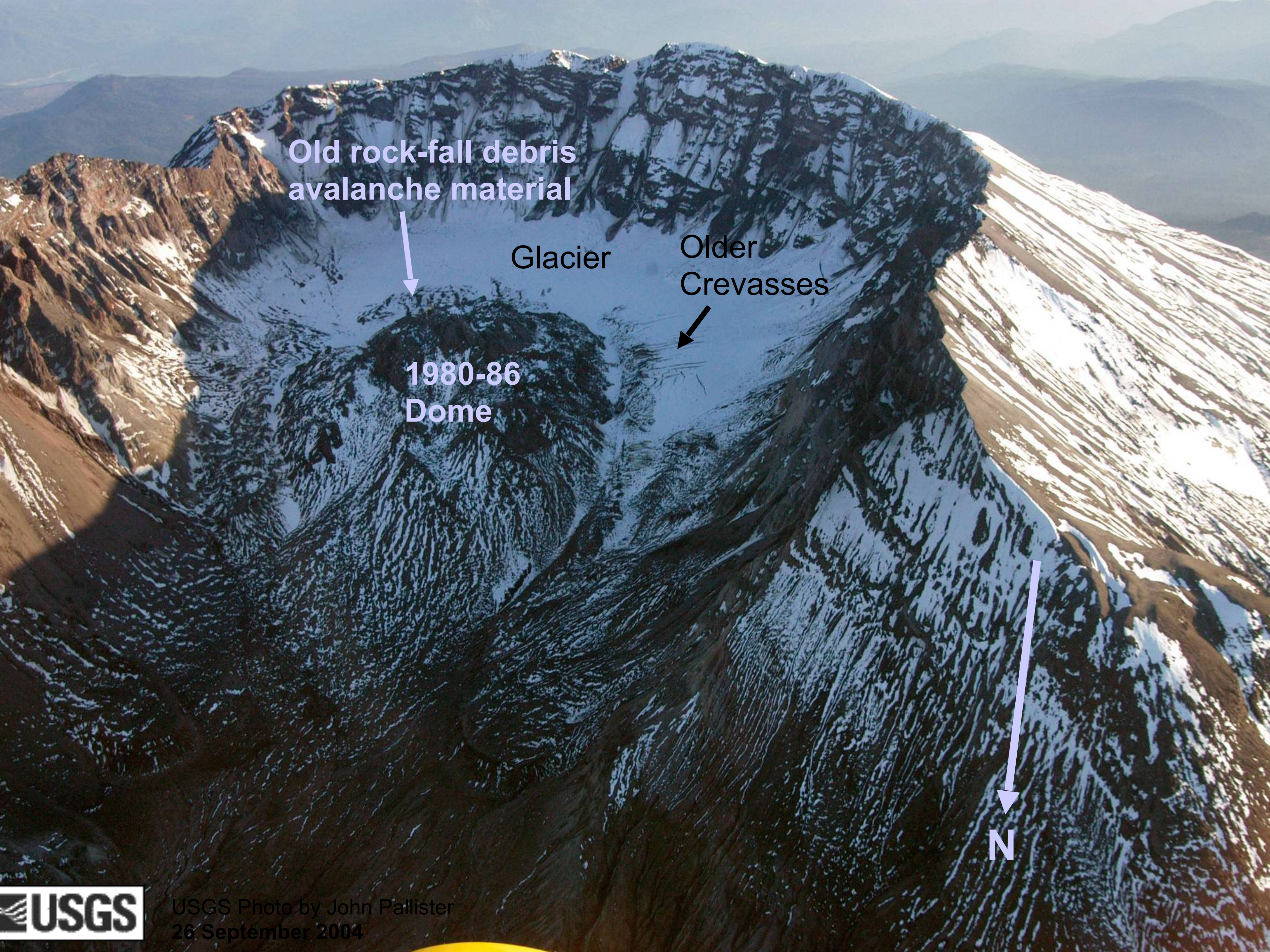
http://www.pnsn.org/WEBICORDER/GREEN/HSR_EHZ_UW.2004100512.html

Short-Period Weak-Motion Webicorders - **Mt. St. Helens quakes can be seen on many stations**

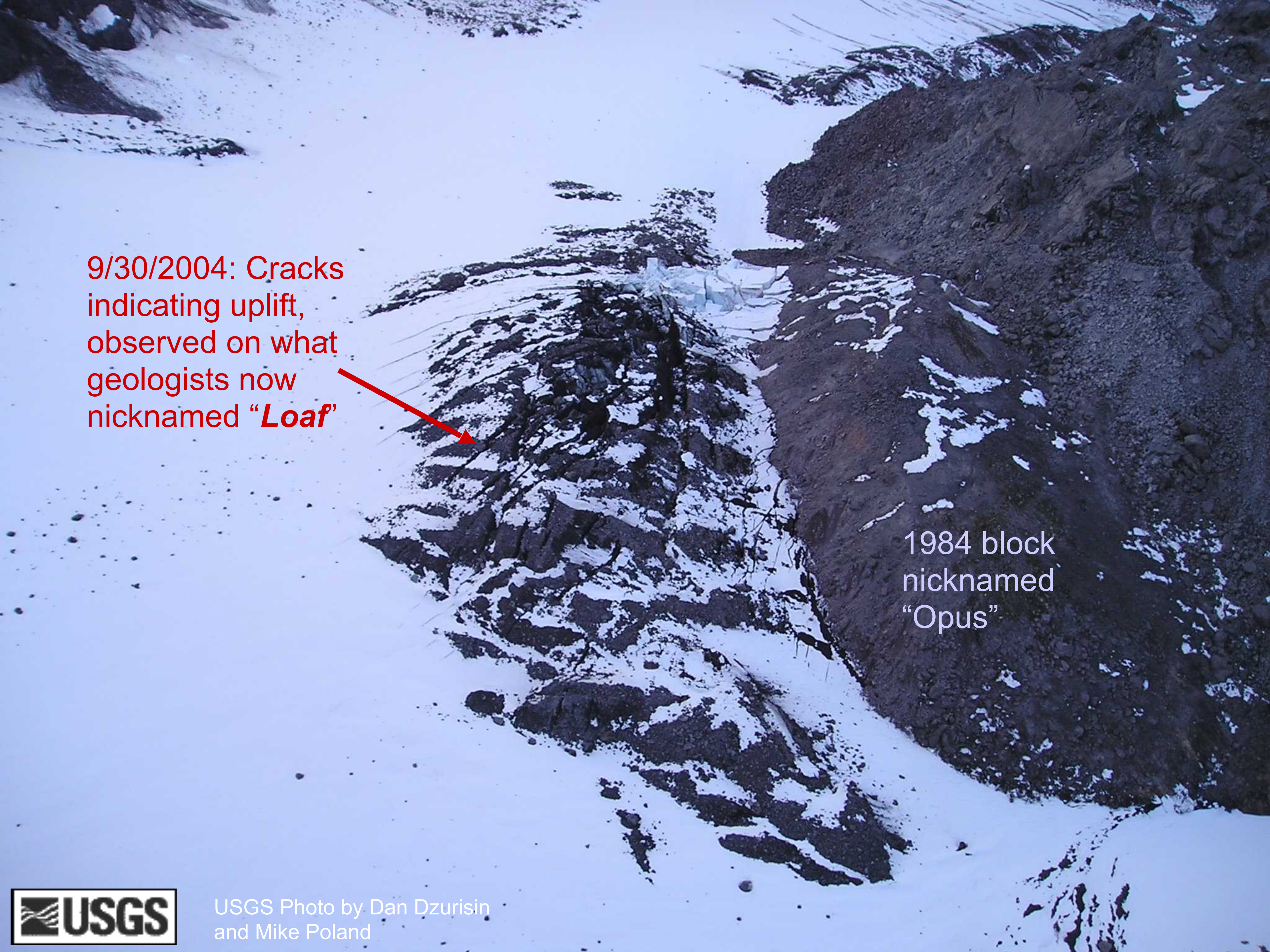
Short-Period ..|.. School-Net [A-M] ..|.. School-Net [N-Z] ..|.. Education Resources ..|.. Latest Quakes

MBW | MCW | RPW | STW | JCW | HTW | GNW | RCS | FMW | LON | CDF | HSR | JUN | HOOD | MOON | HUO | DBO | FRIS | RSW |

Drop in seismicity following the October 5 steam-and-ash emission



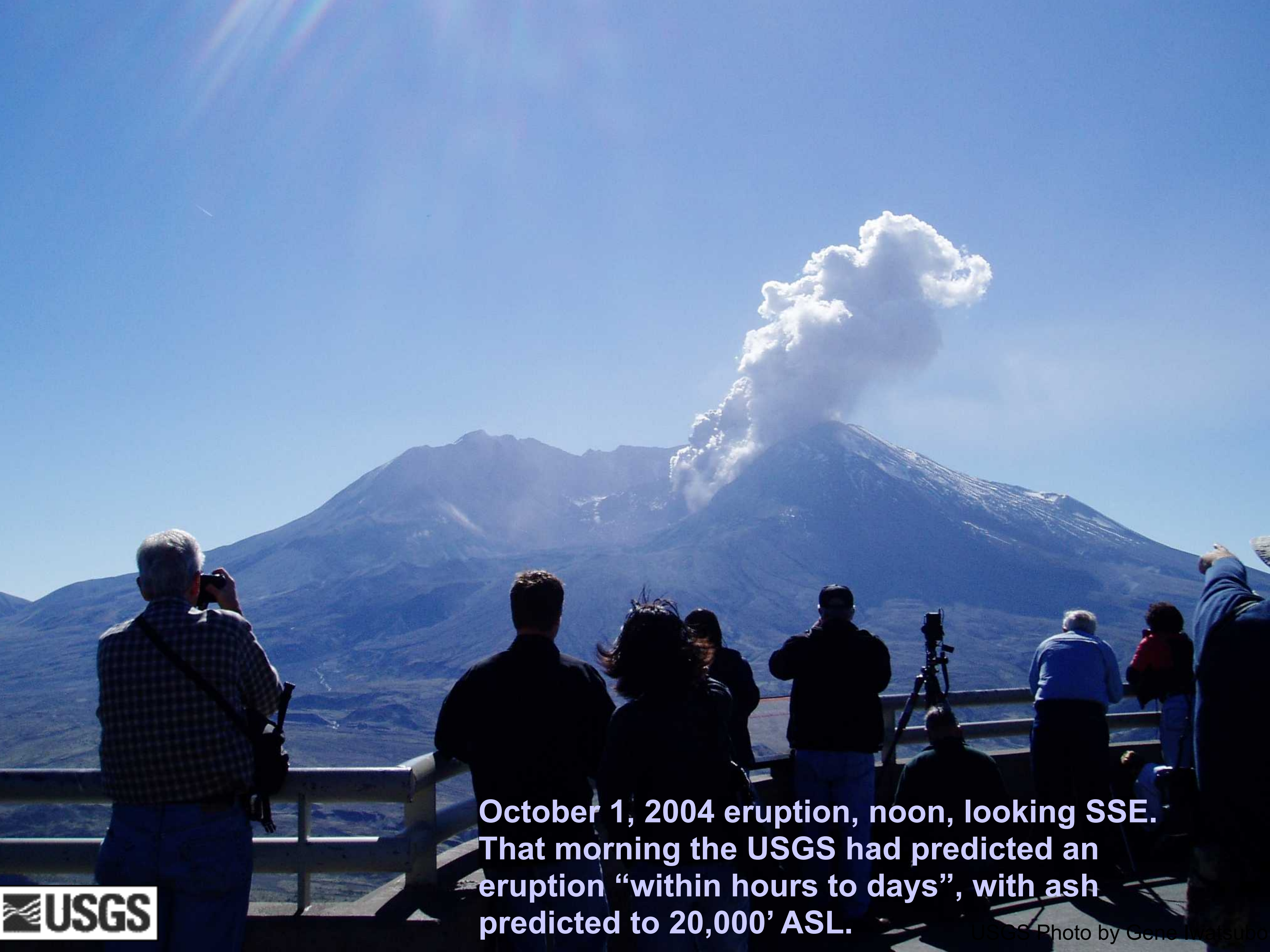
USGS Photo by John Pallister
26 September 2004



9/30/2004: Cracks indicating uplift, observed on what geologists now nicknamed “***Loaf***”

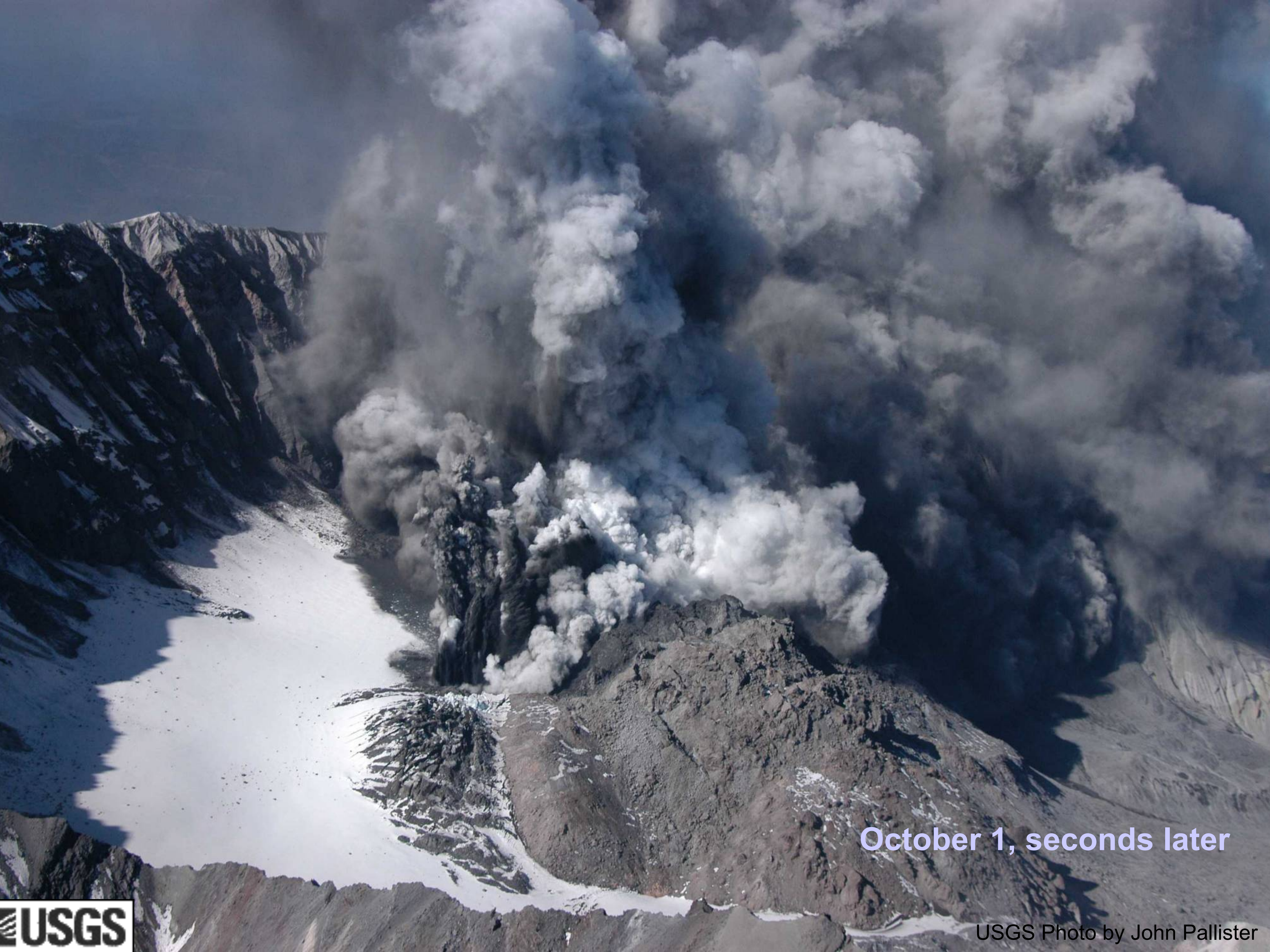
1984 block nicknamed “Opus”

USGS Photo by Dan Dzurisin and Mike Poland



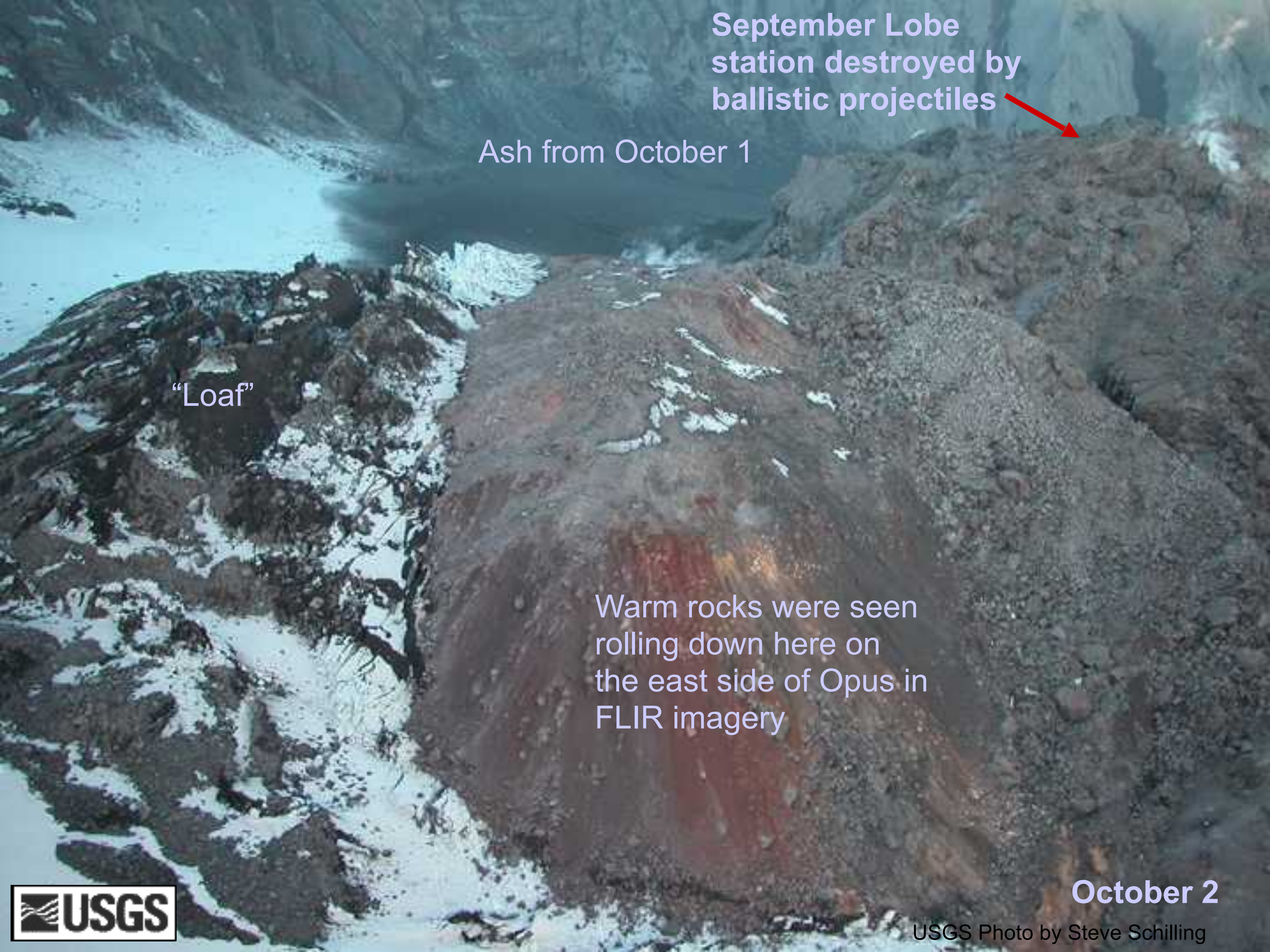
October 1, 2004 eruption, noon, looking SSE. That morning the USGS had predicted an eruption “within hours to days”, with ash predicted to 20,000’ ASL.

USGS Photo by Gene Iwatsubo



October 1, seconds later

USGS Photo by John Pallister



September Lobe station destroyed by ballistic projectiles

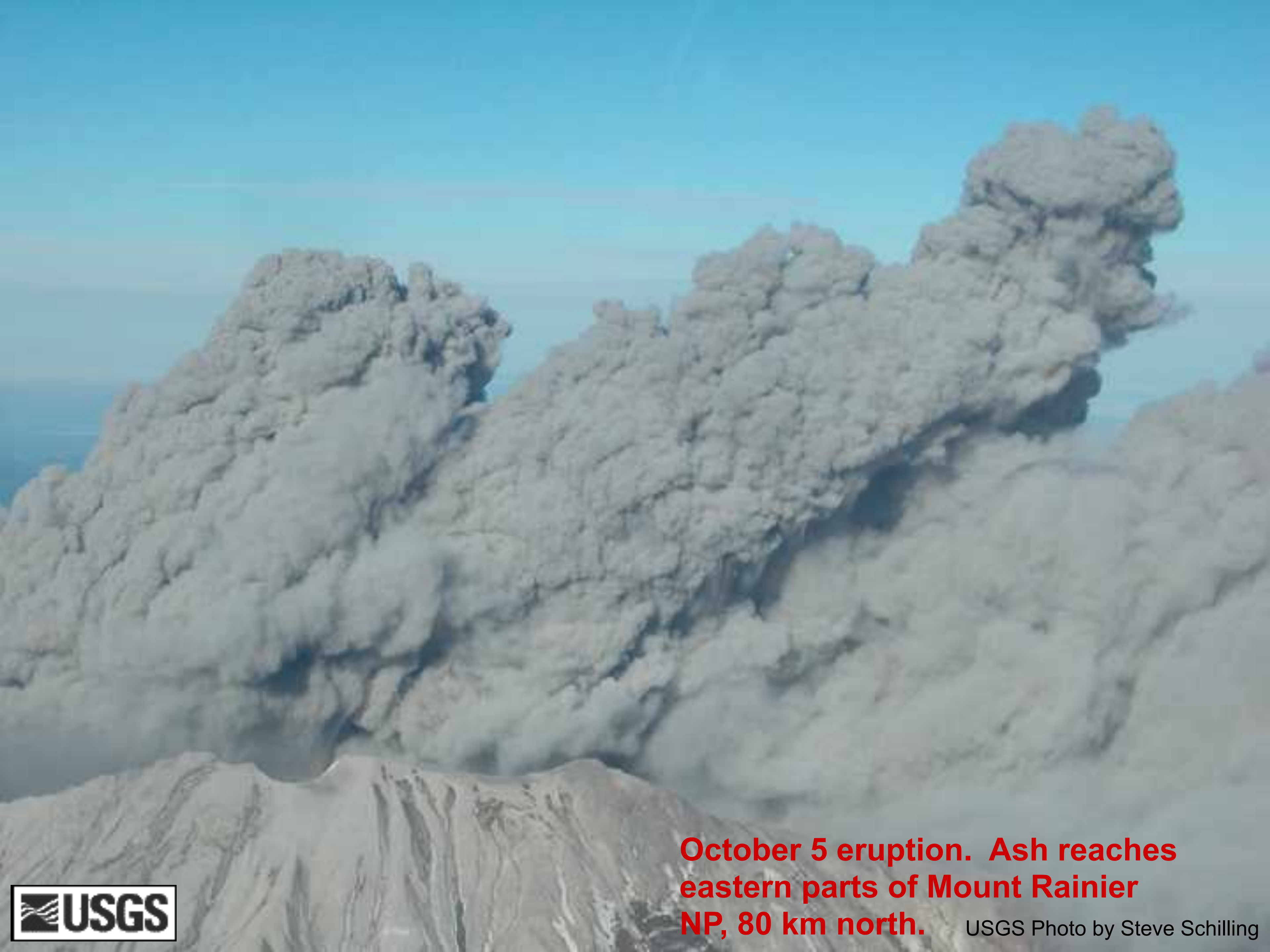
Ash from October 1

“Loaf”

Warm rocks were seen rolling down here on the east side of Opus in FLIR imagery

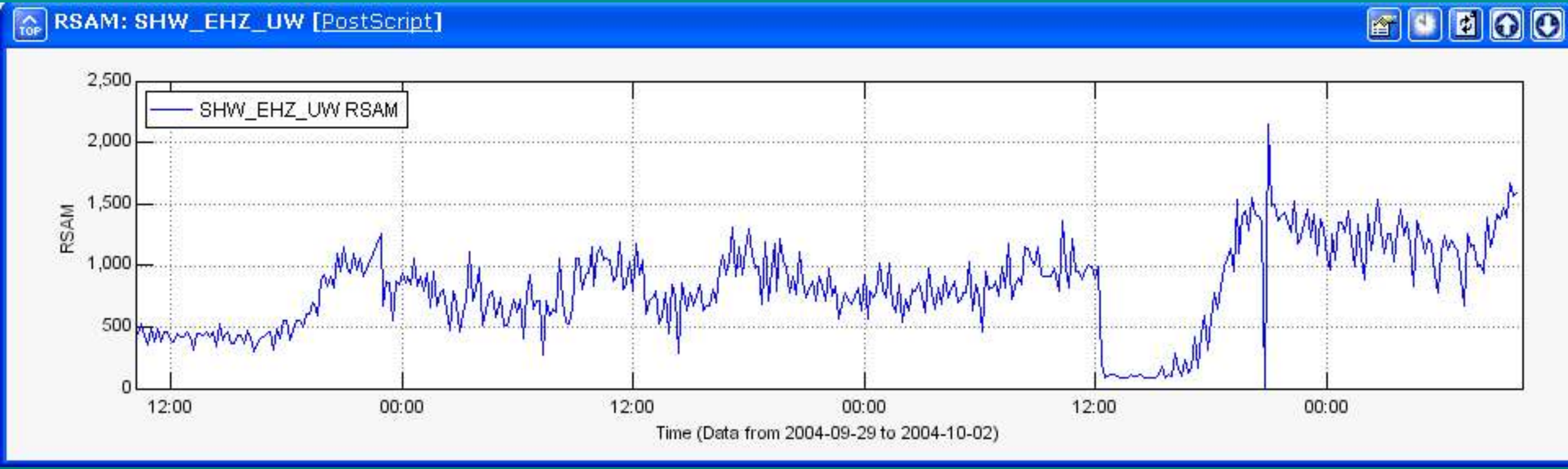
October 2

USGS Photo by Steve Schilling



October 5 eruption. Ash reaches eastern parts of Mount Rainier NP, 80 km north.

USGS Photo by Steve Schilling



These “RSAM” plots show seismic energy through time. Seismic activity dropped off abruptly after the October 1 eruption - but then built back up again. RSAM refers to Real-Time Seismic Amplitude measurement, an automated technique for tracking seismic energy that was developed at CVO during the 1980’s.

↑

October 1
Eruption

Gas flights begin Monday, Sept 27. These flights are looking for magmatic gas concentrations that exceed normal background.

USGS Photo by Steve Schilling

An example of a helical gas-flight within the crater

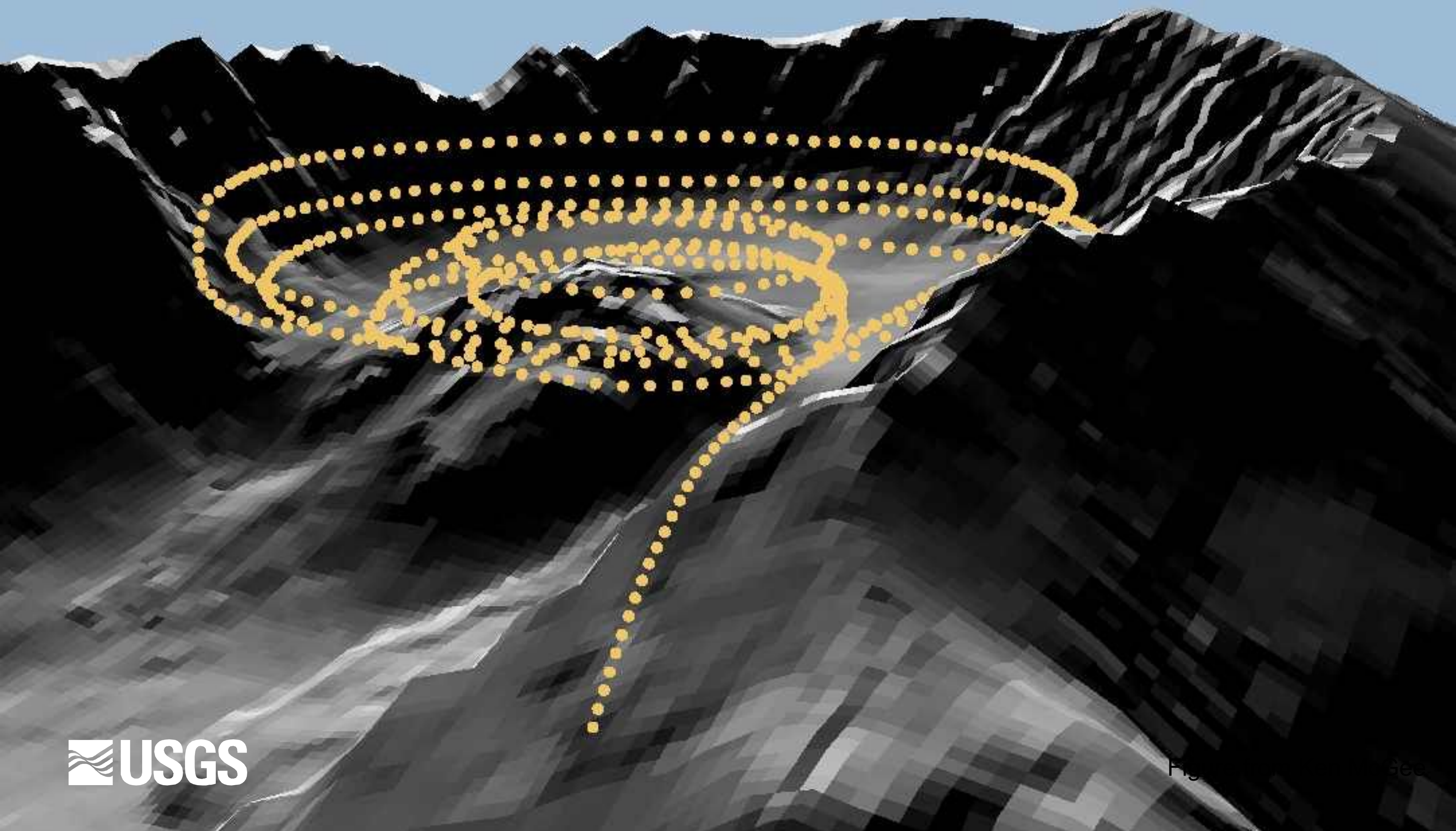
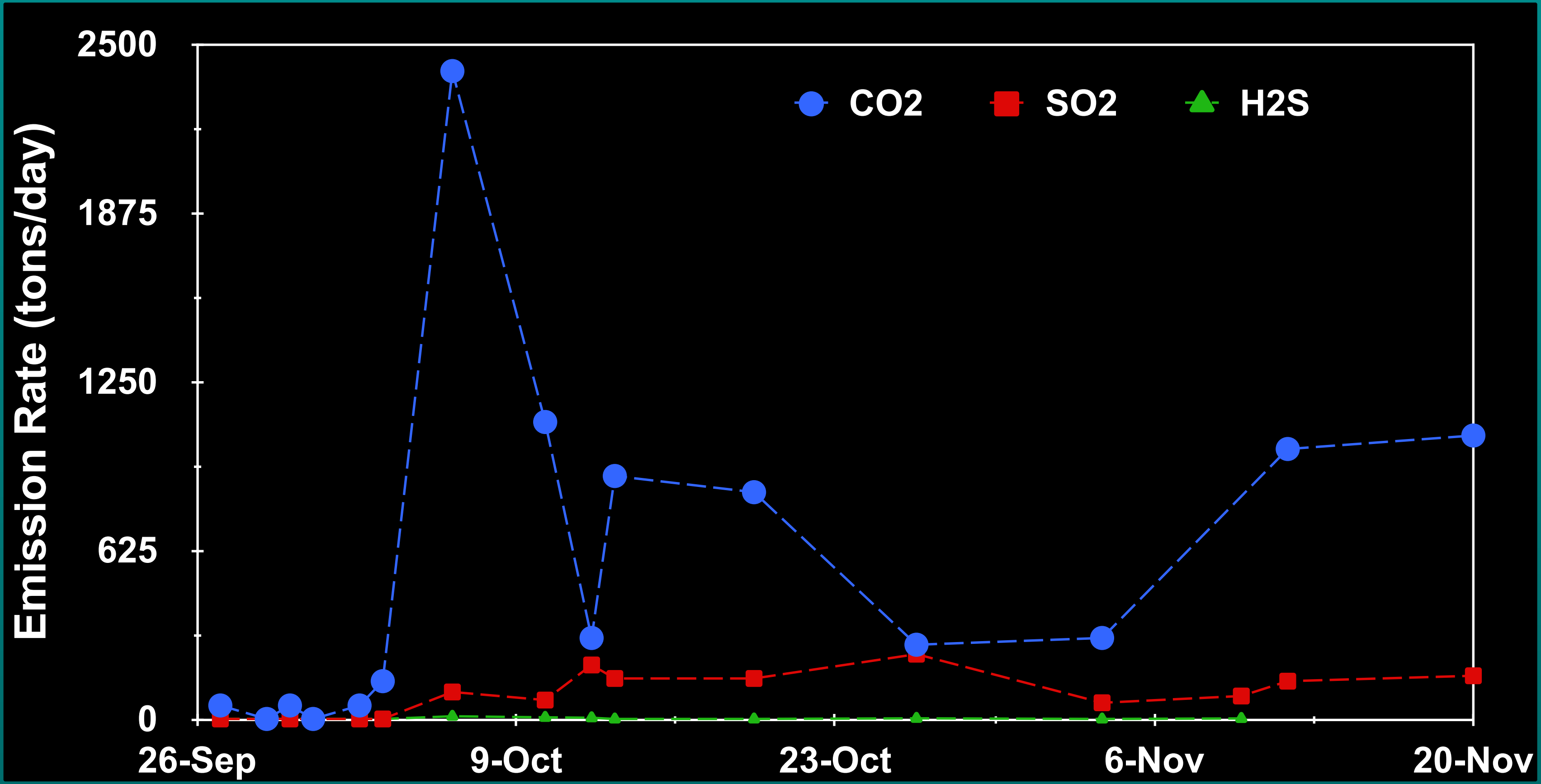
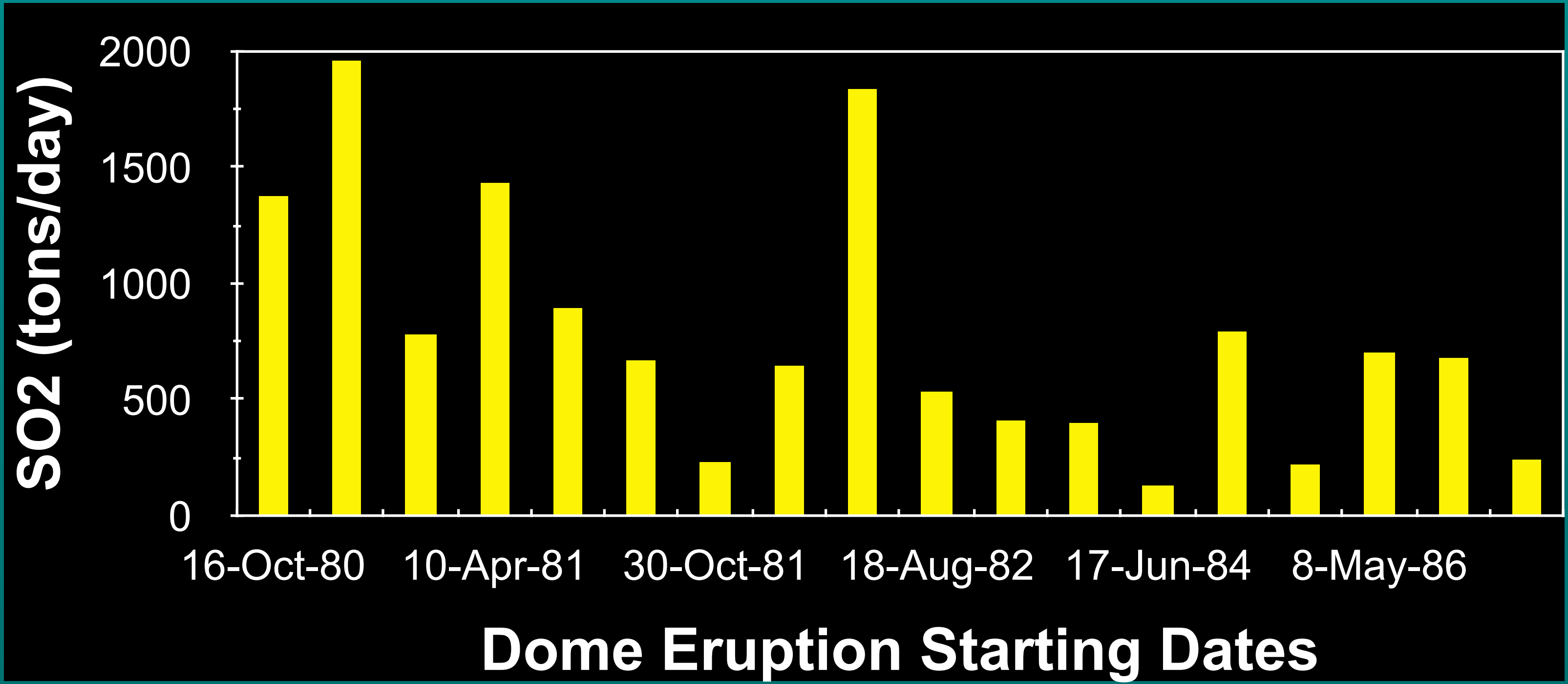


Figure from Ken McGee

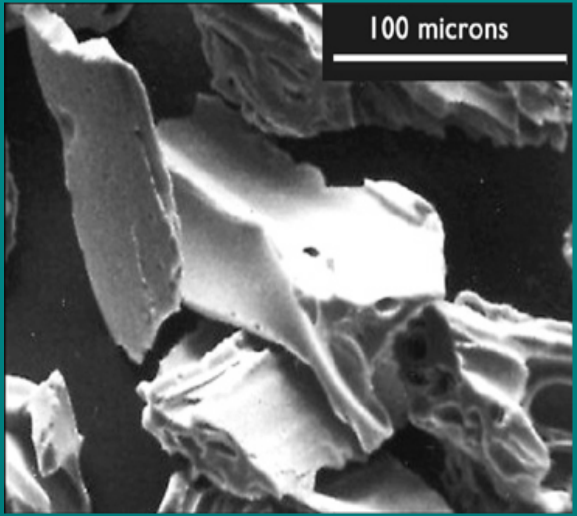
Gas emission rates



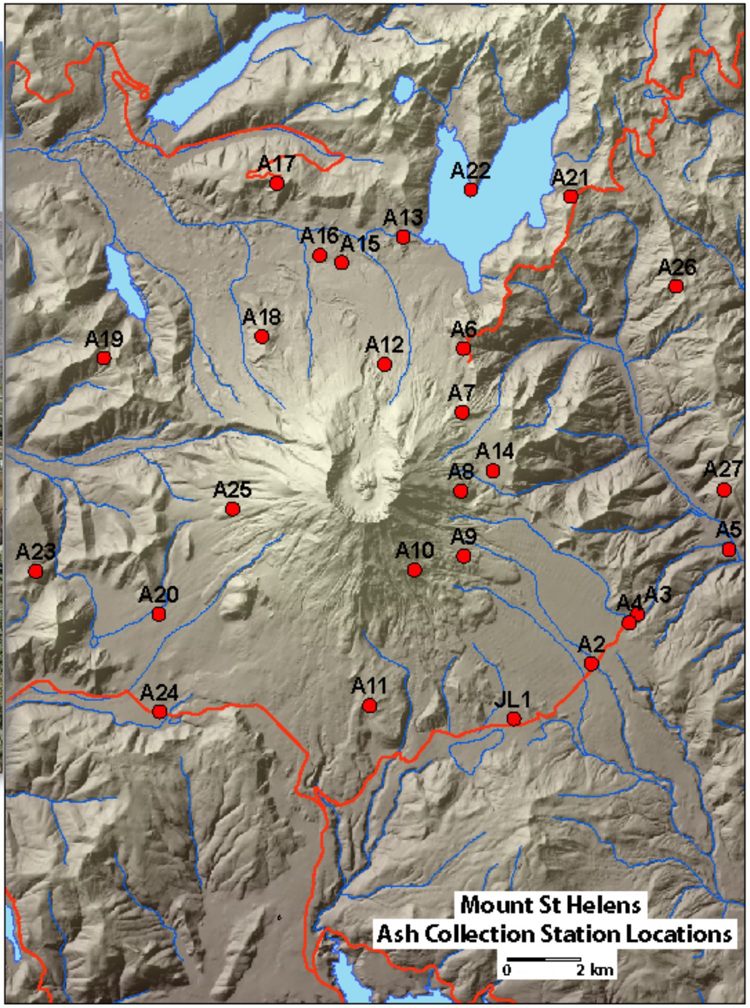
Dome eruption peak SO_2 emissions



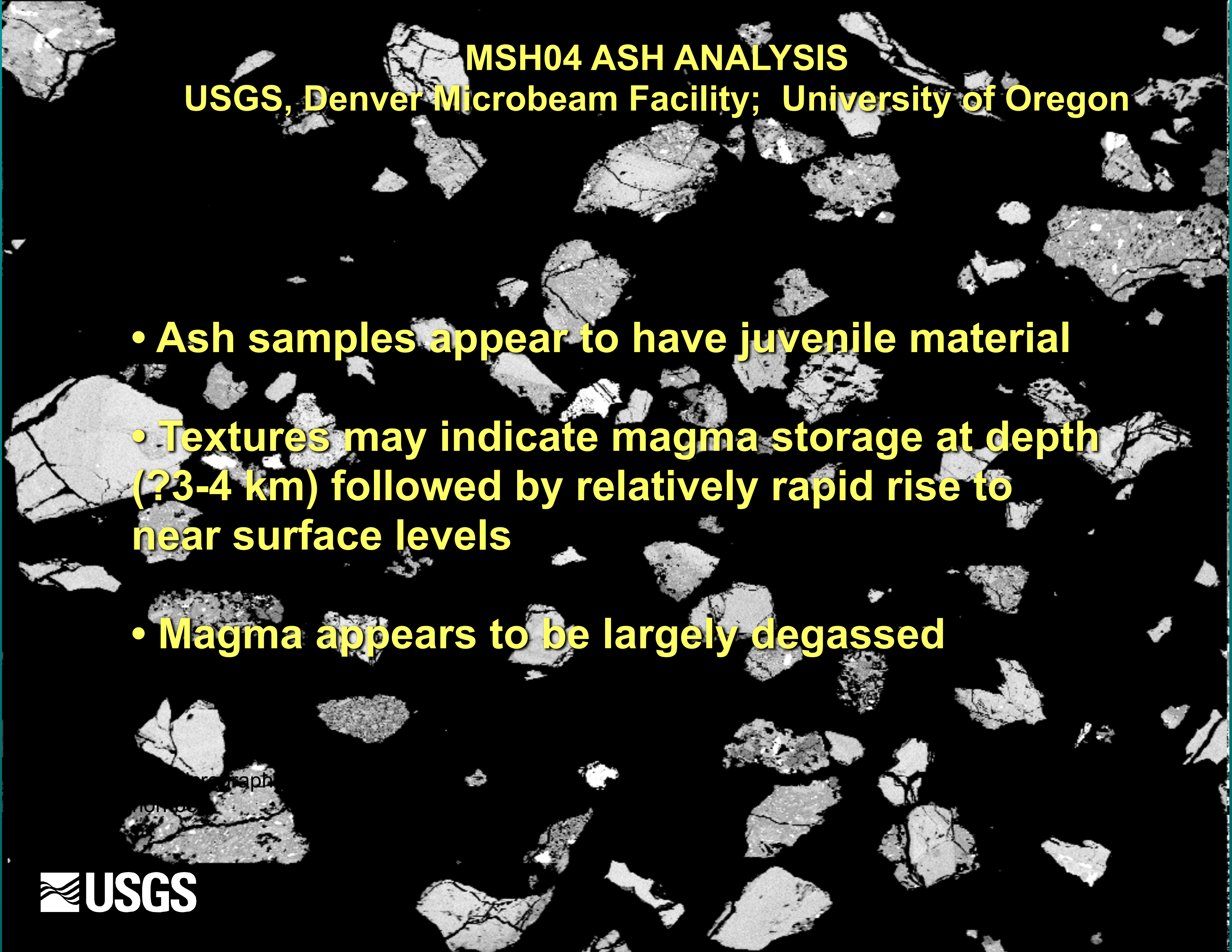
Ash tells us something about the magma... are we seeing pulverized old rock, or is it new, volatile-rich (and potentially explosive) magma?



Network of stations for MSH Ash collection
In place in mid October 2004

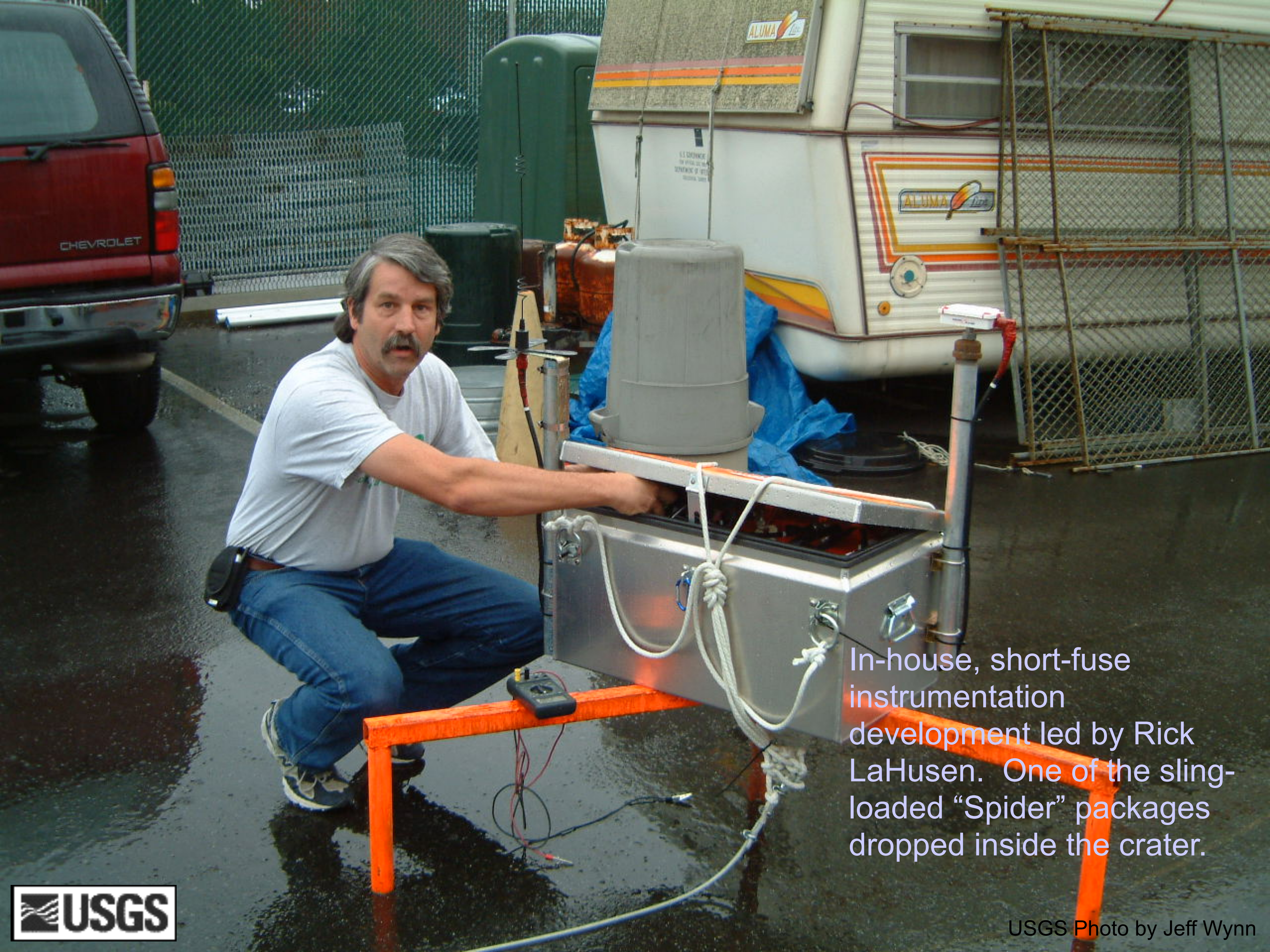


USGS



MSH04 ASH ANALYSIS
USGS, Denver Microbeam Facility; University of Oregon

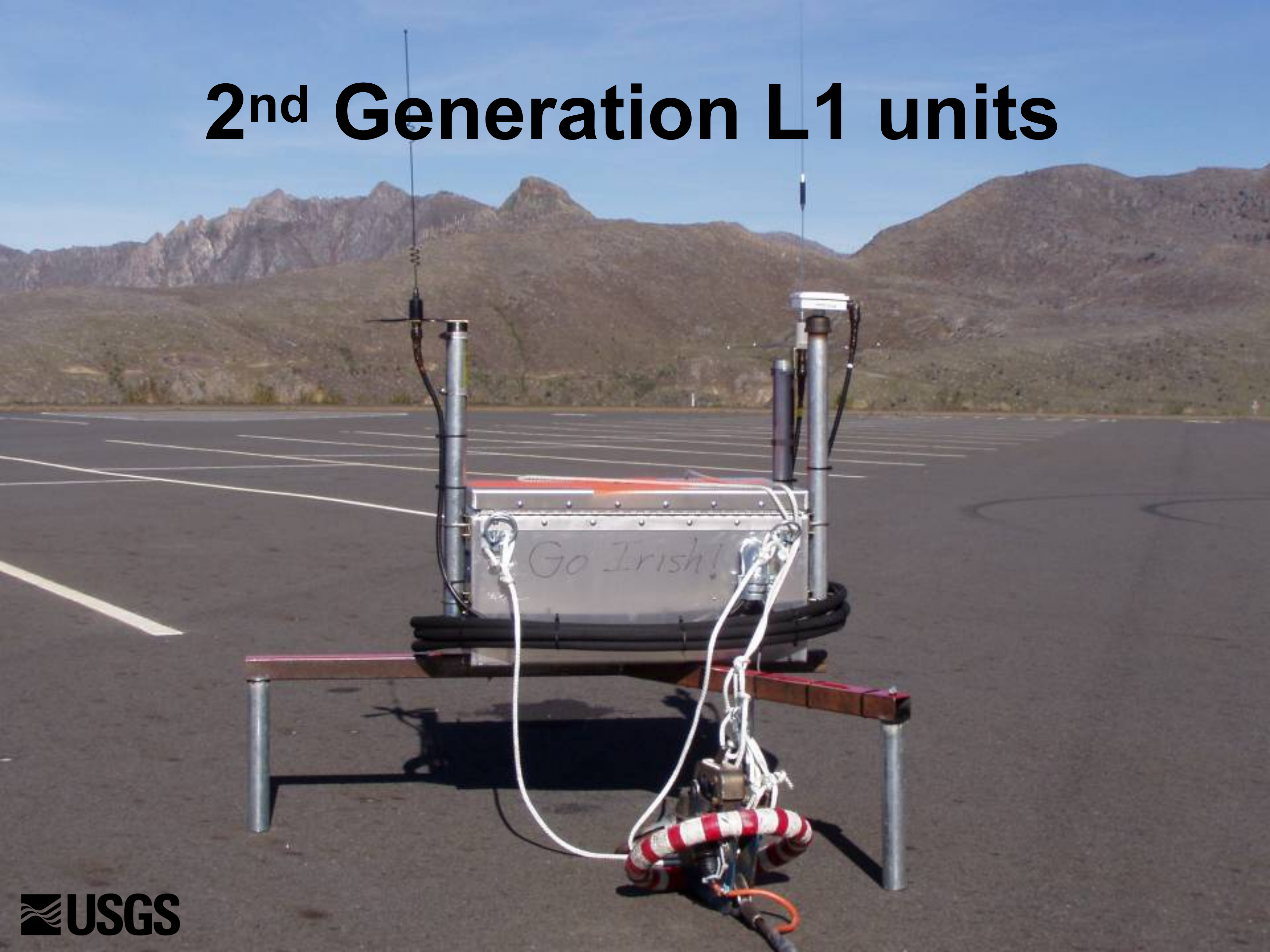
- Ash samples appear to have juvenile material
- Textures may indicate magma storage at depth (?3-4 km) followed by relatively rapid rise to near surface levels
- Magma appears to be largely degassed



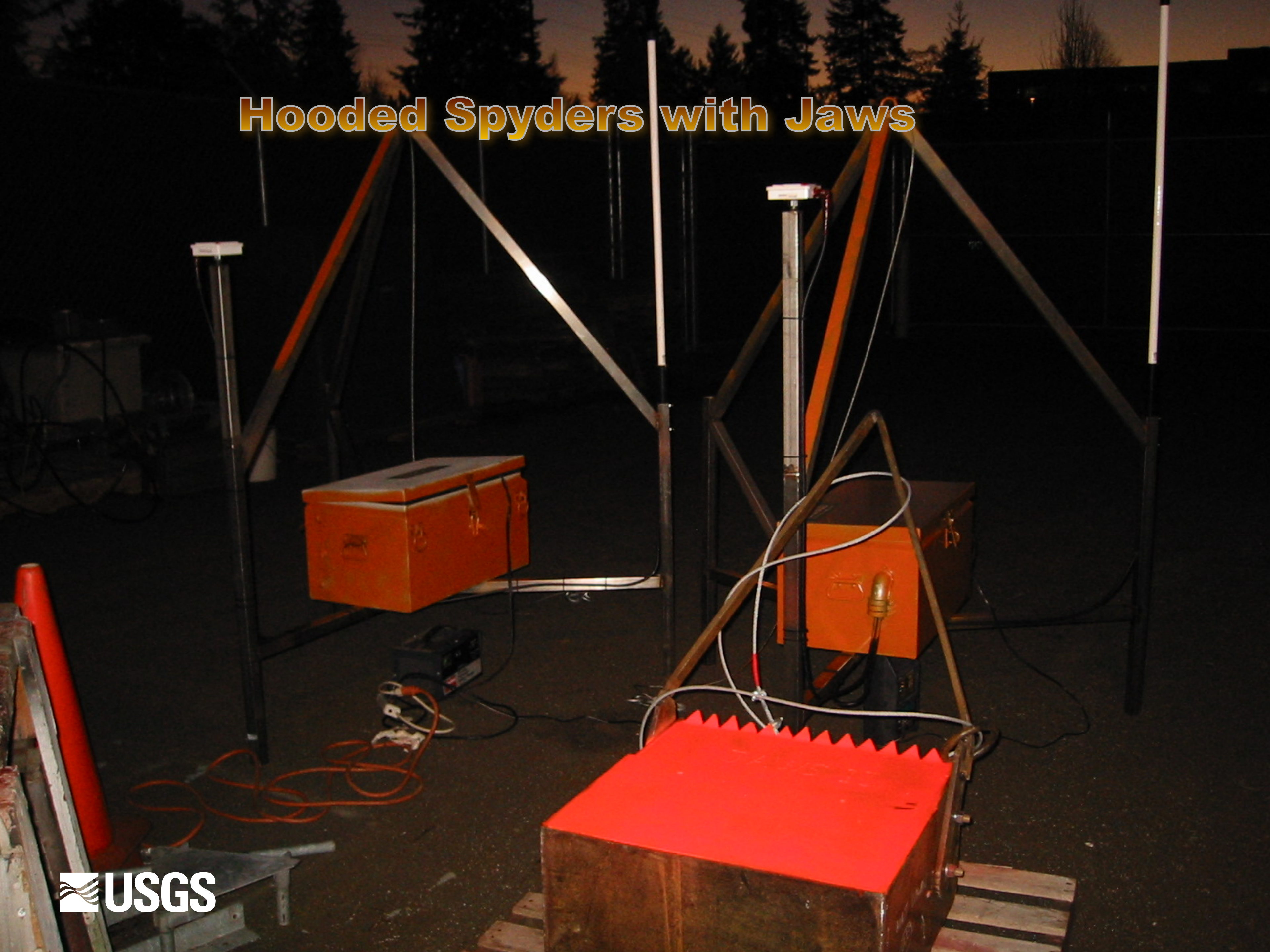
In-house, short-fuse instrumentation development led by Rick LaHusen. One of the sling-loaded “Spider” packages dropped inside the crater.

USGS Photo by Jeff Wynn

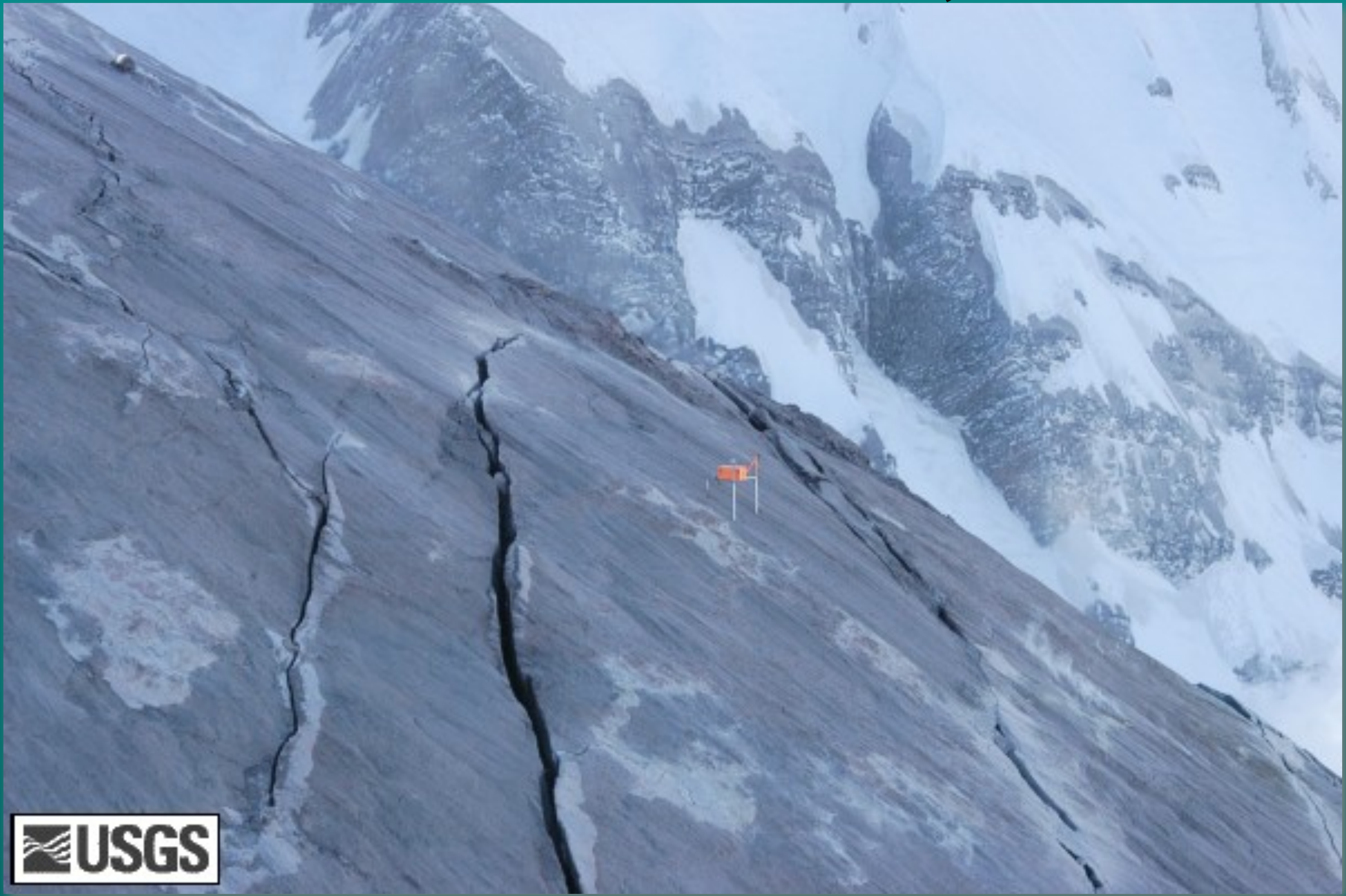
2nd Generation L1 units



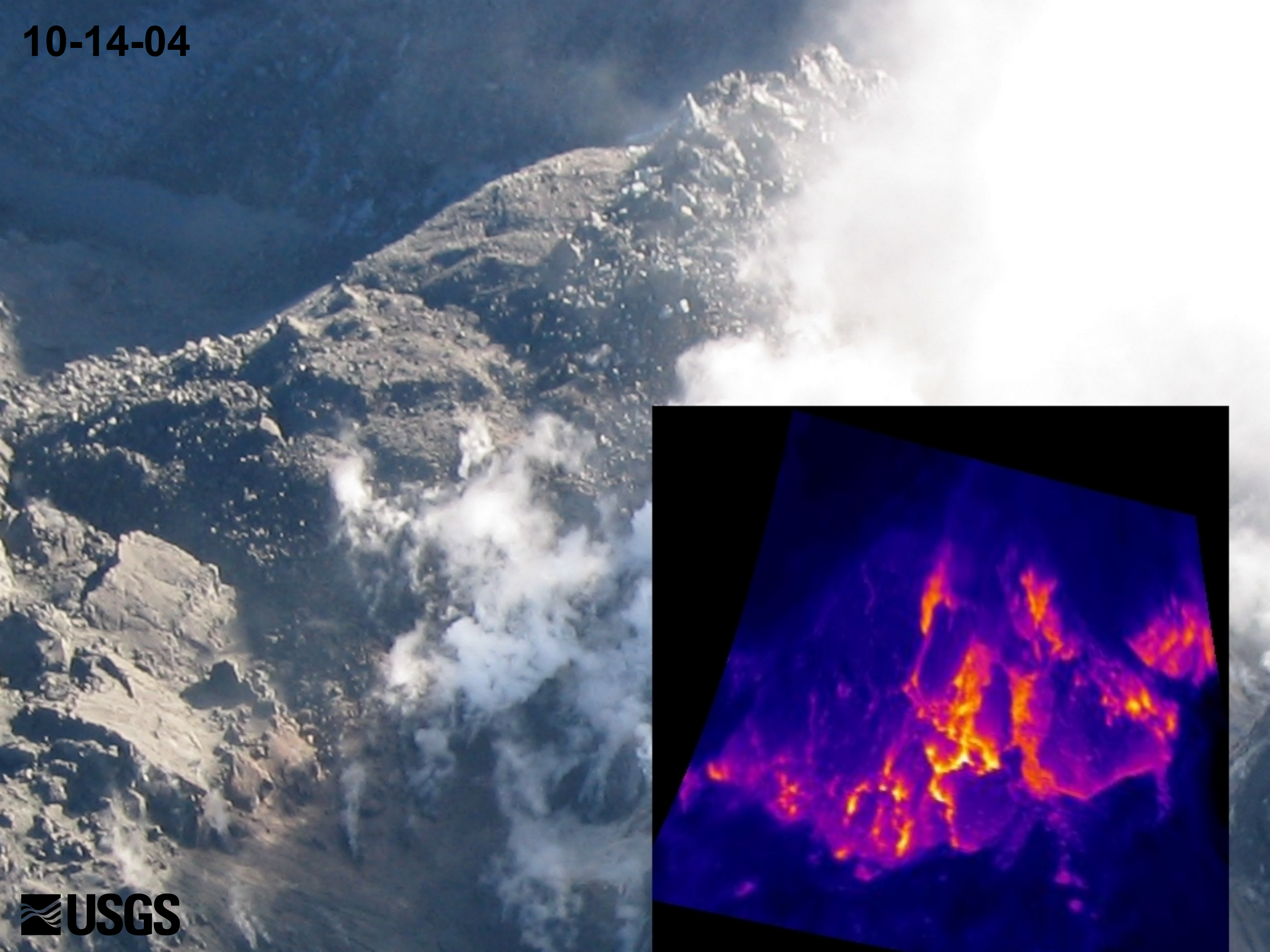
Hooded Spyders with Jaws



GPS/Accelerometer "spider" on north face of new dome. Jan 14, 2005

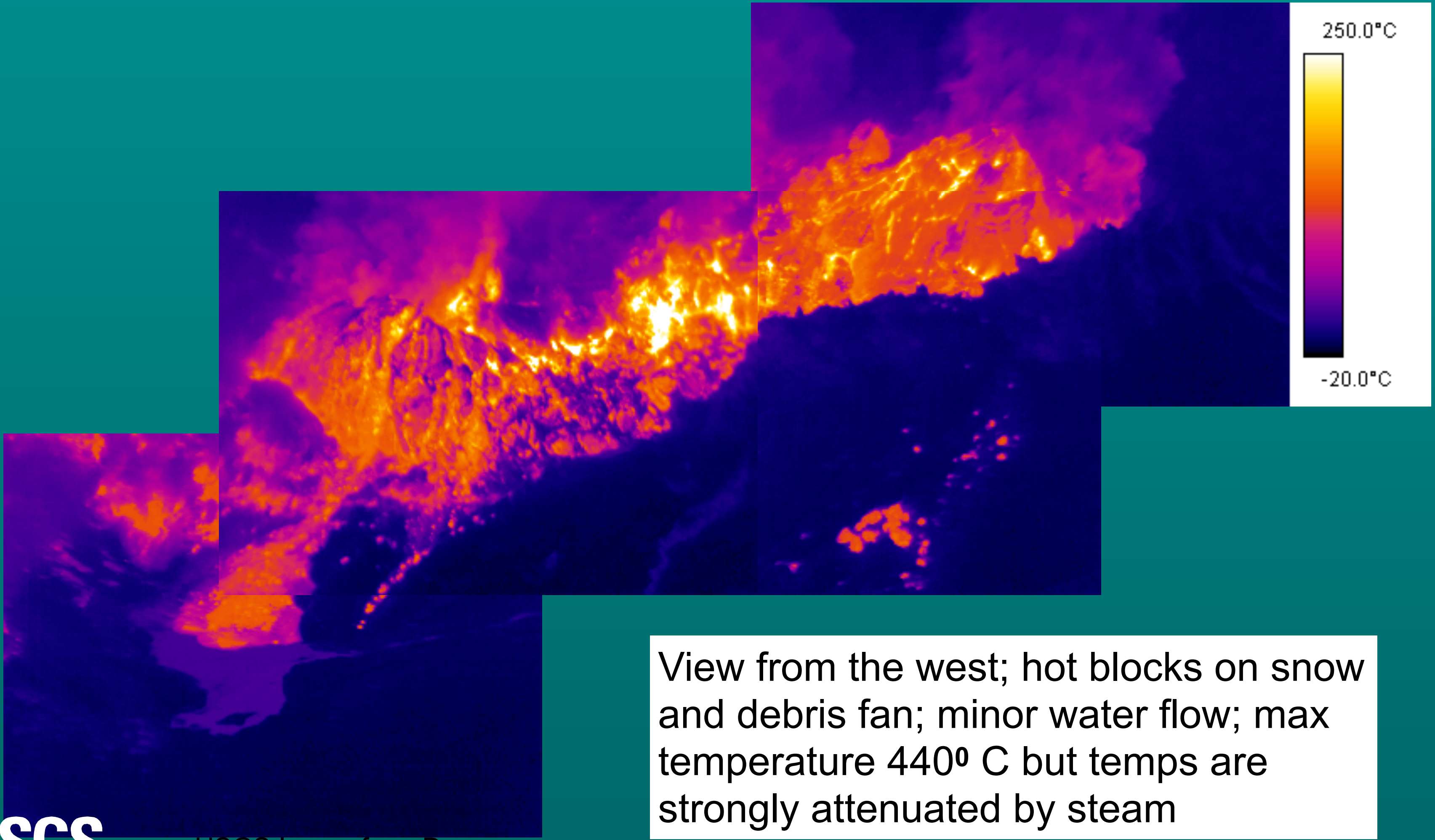


02-01-05



10-14-04

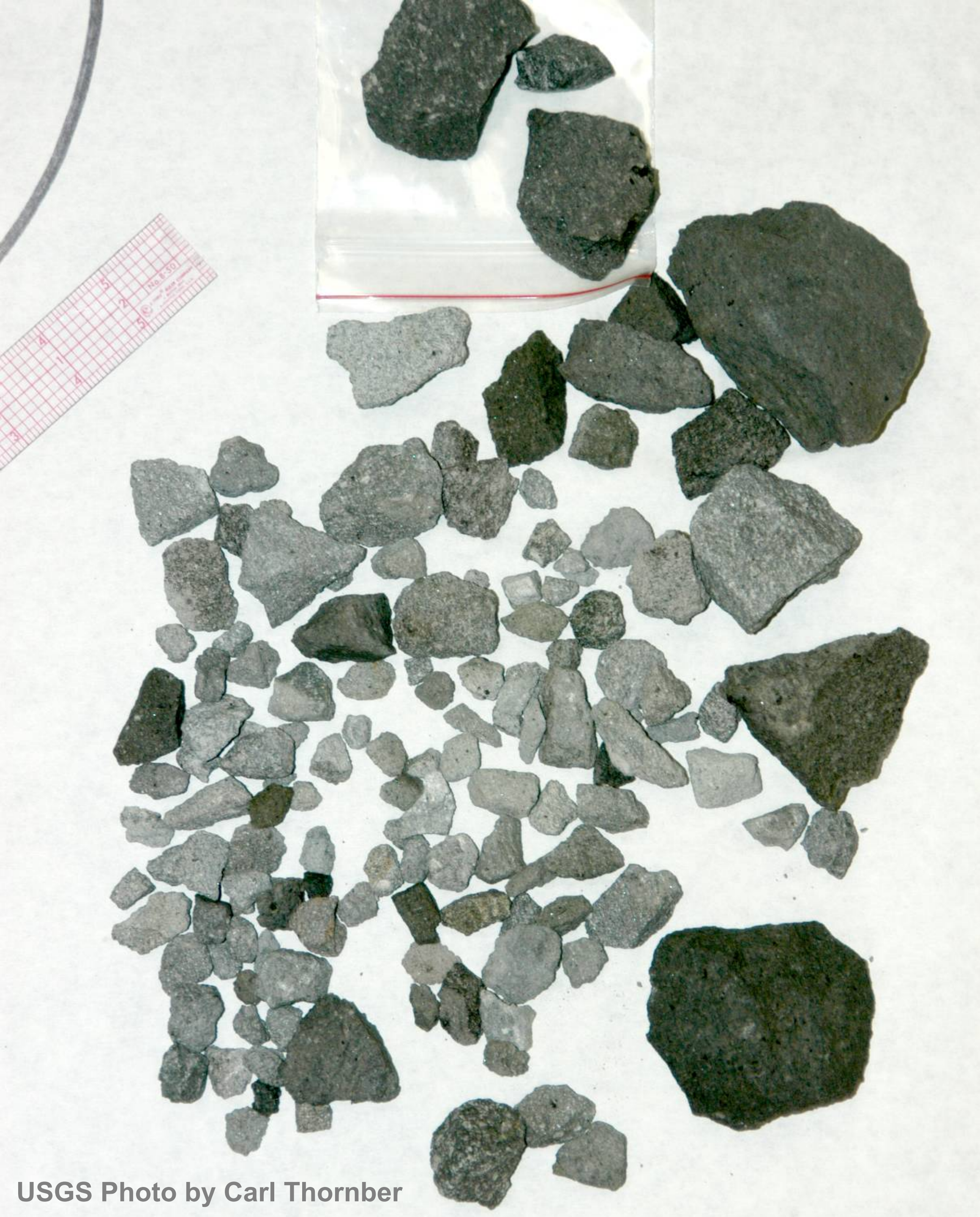
October 24, 2004 FLIR Image:



View from the west; hot blocks on snow and debris fan; minor water flow; max temperature 440^0 C but temps are strongly attenuated by steam

USGS Image from Dave Schneider

Sampling Methods


USGS Photo by Carl Thornber

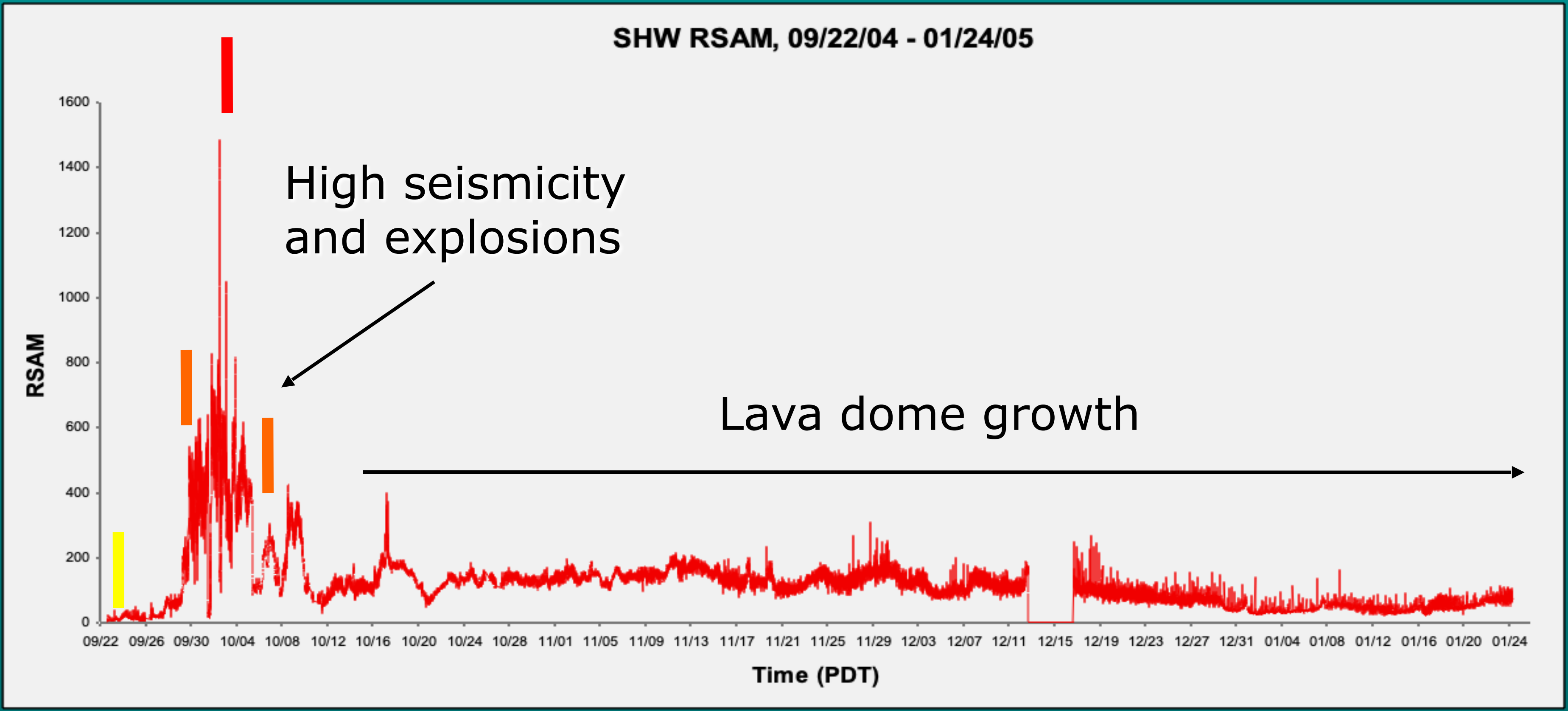
The first samples of new dacite magma, collected by a steel bucket on a rope: clinopyroxene-bearing hornblende dacite

– similar to 1980's MSH, but several percent (65.3%) higher in silica content.

USGS

USGS

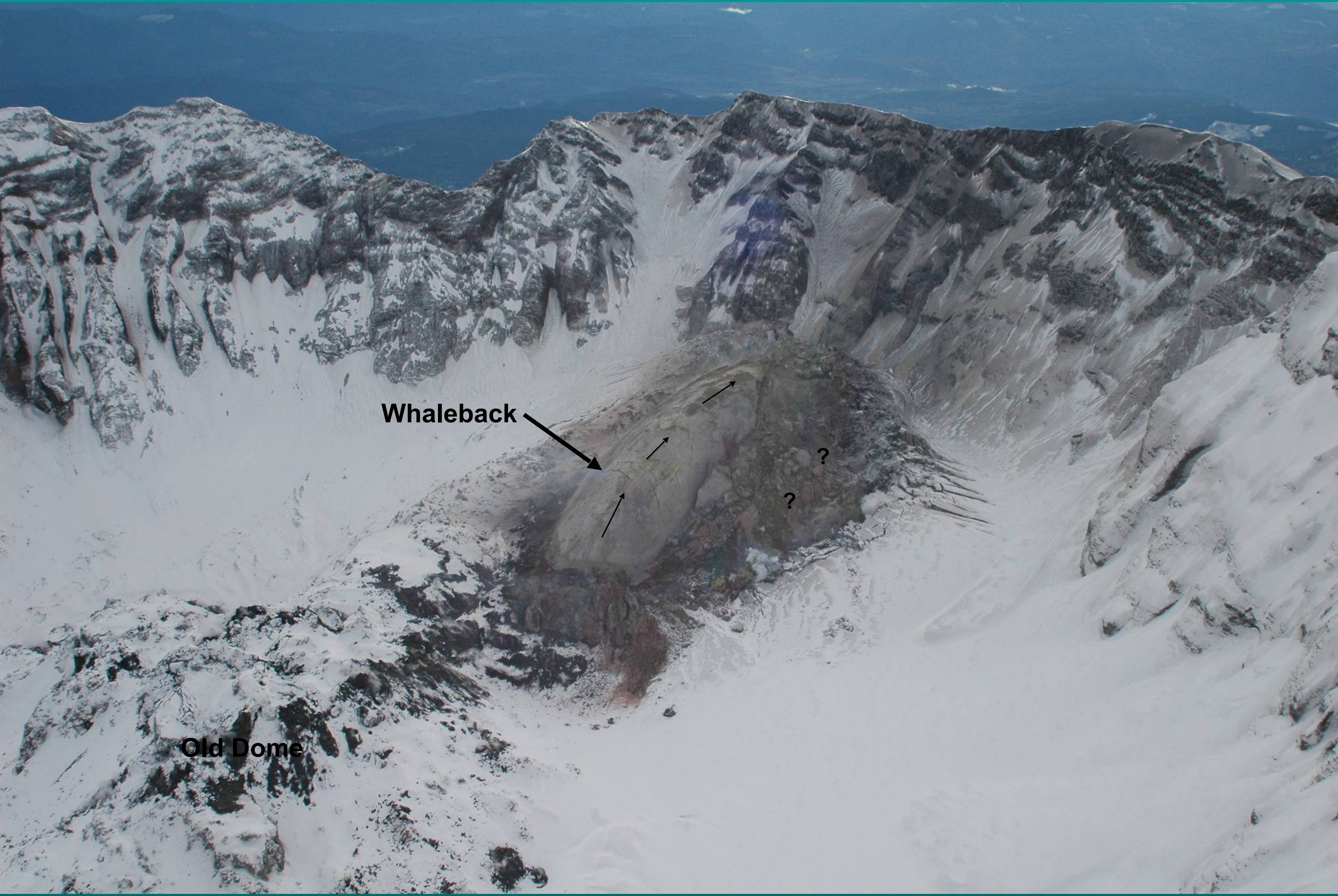
Volcanic Events and Alert Levels



High seismicity and explosions

Lava dome growth

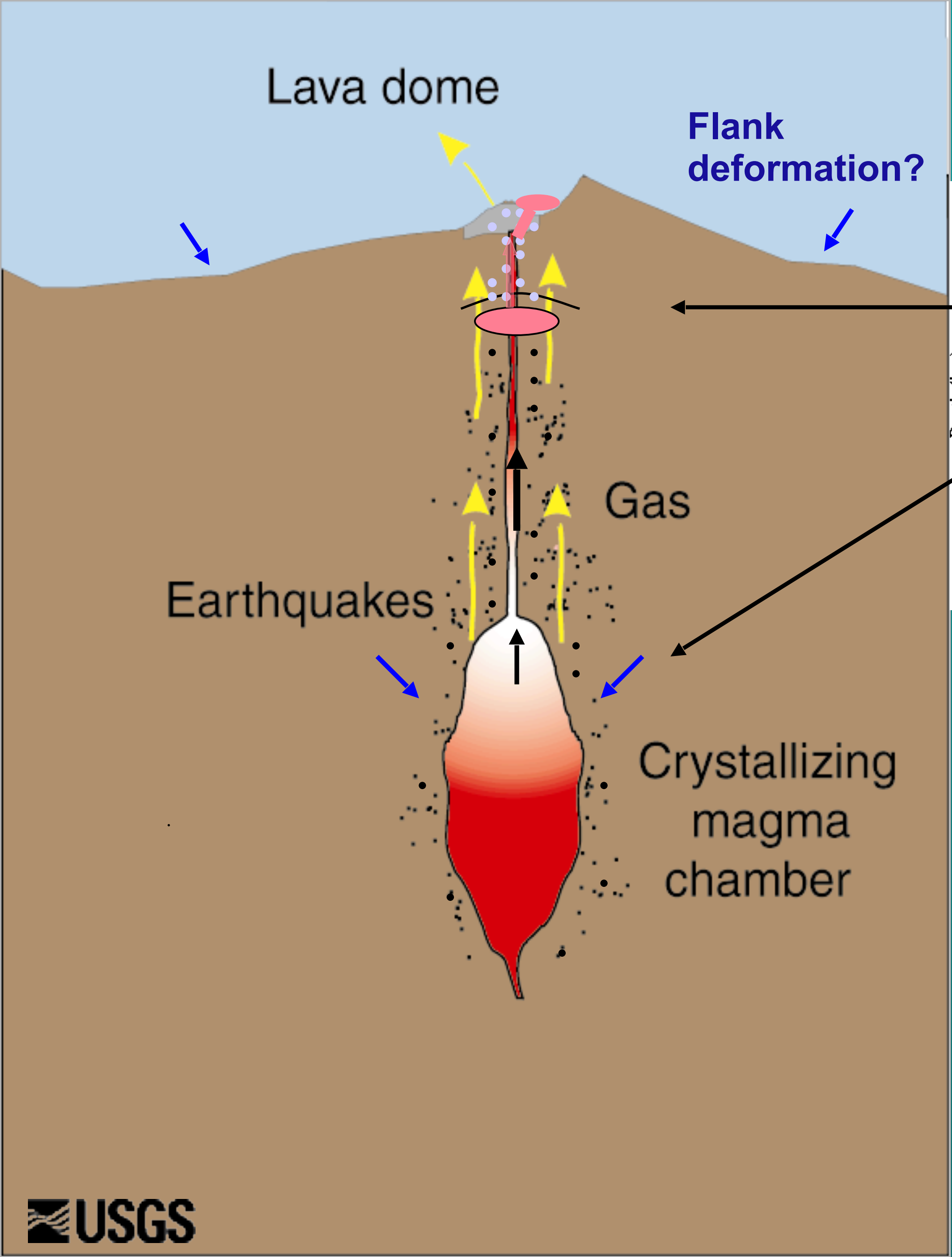
- 🟥 AL 3 Volcano Alert
- 🟧 AL 2 Volcano Advisory
- 🟨 AL 1 Notice of Volcanic Unrest

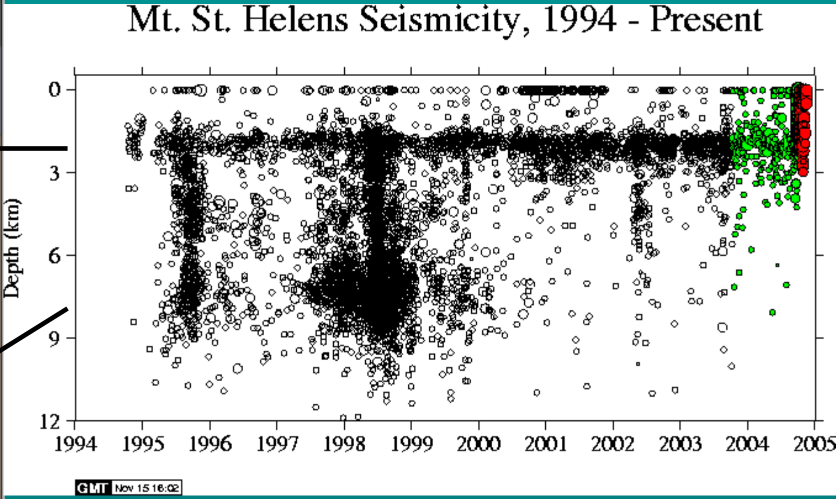


USGS

USGS Photo by John Pallister, 29 November 2004

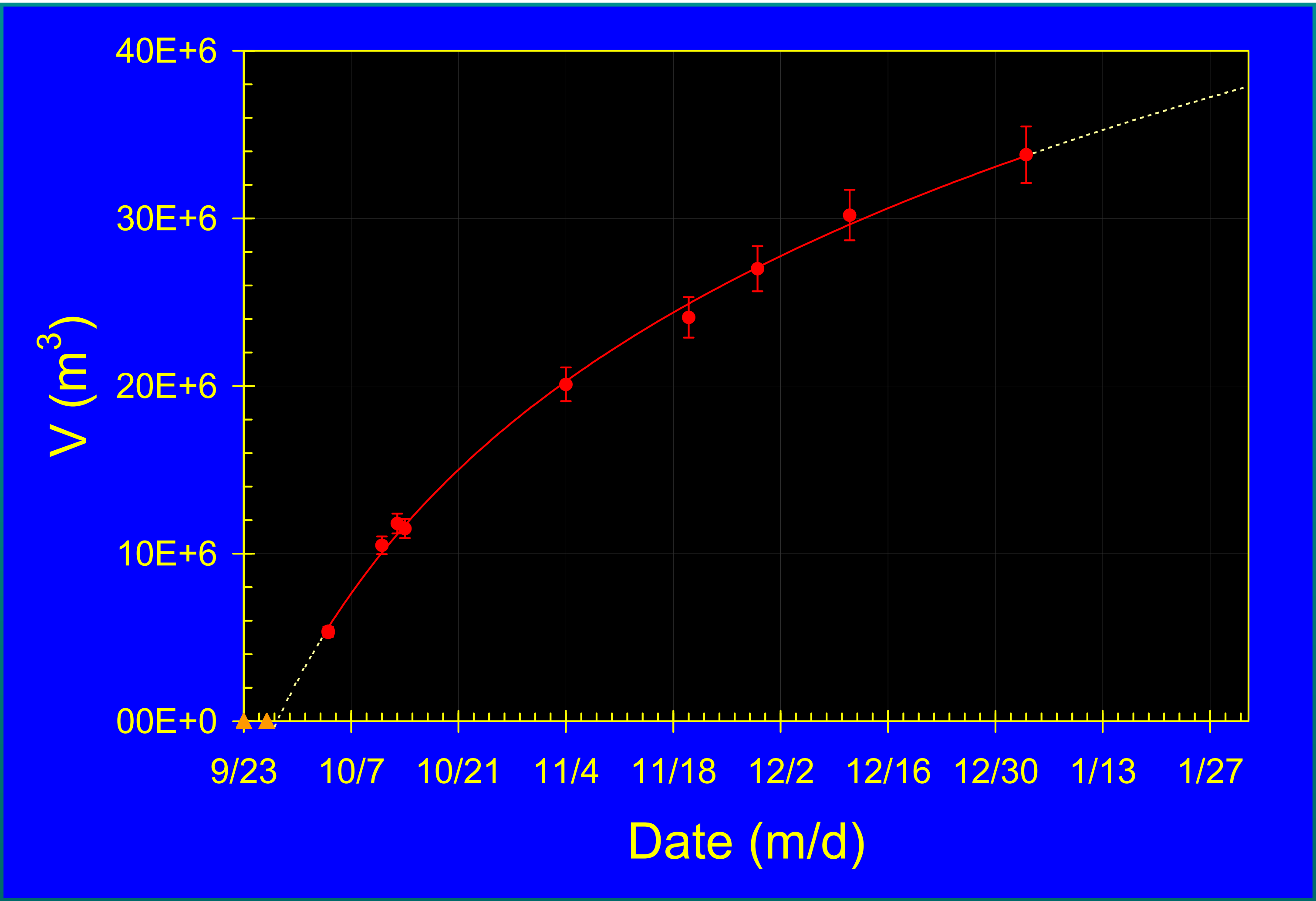
What lies below?

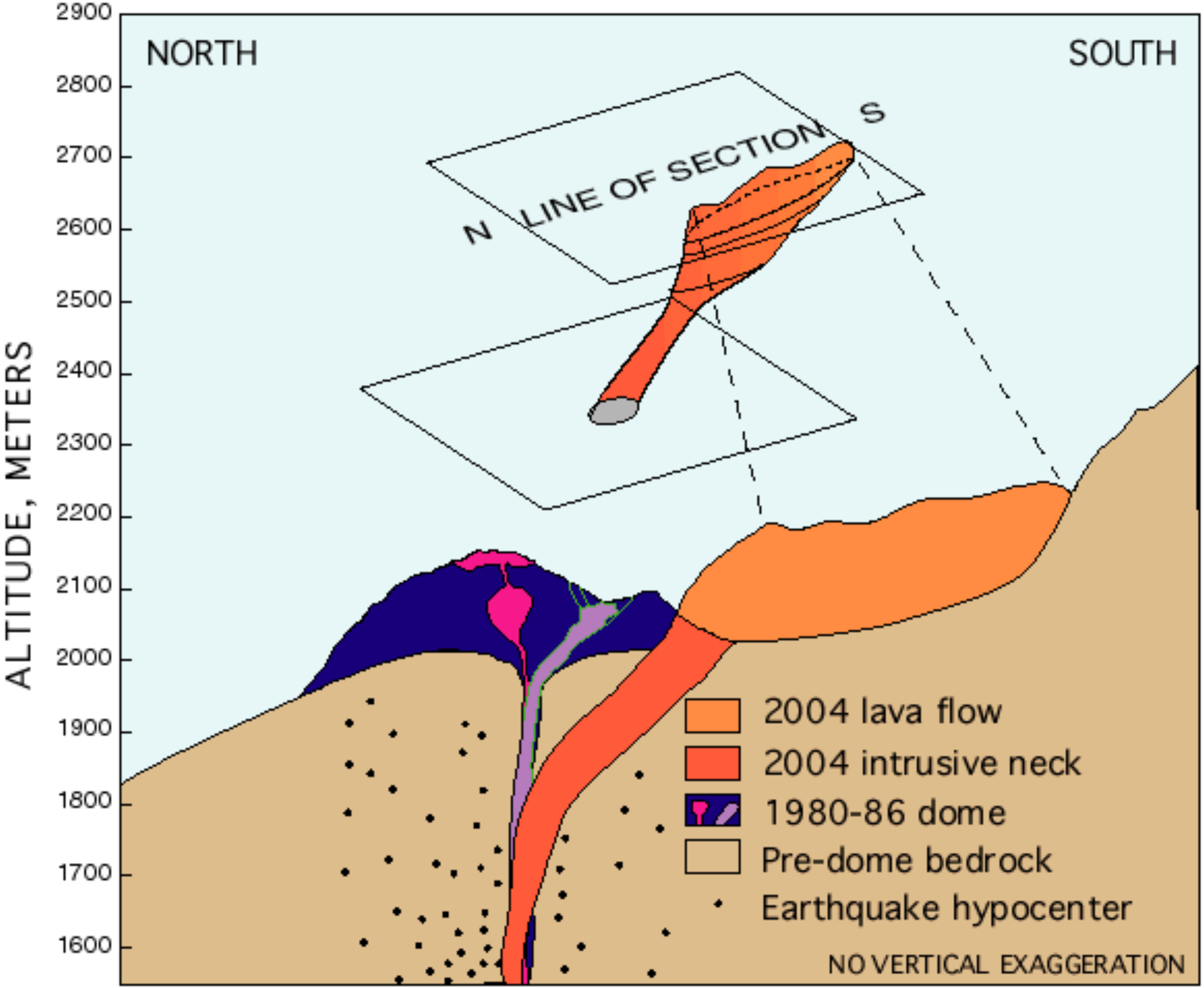



Mt. St. Helens Seismicity, 1994 - Present

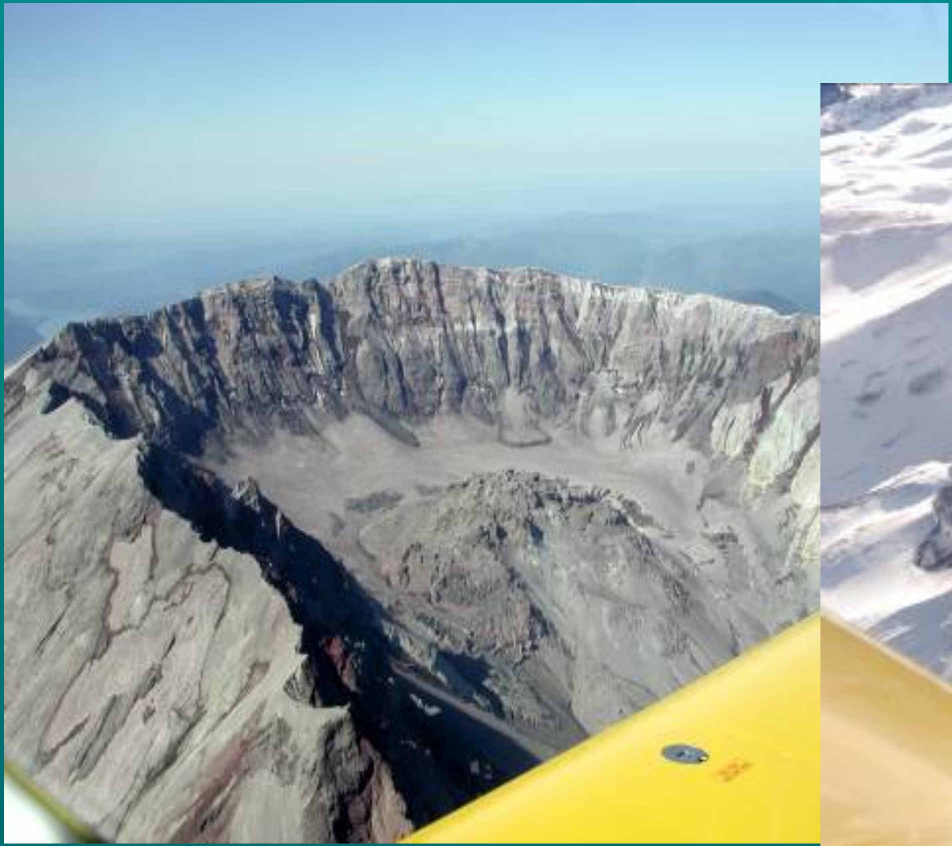
- Leaks of magma & ponding at 2-3 km (e.g., ‘98 - below hydrothermal cap?)
- Rapid ascent from ~ 2-3 km to surface (2004)
- Degassing & crystallization at shallow levels, producing highly viscous dacite lava dome (2004)

Dome Volume increase over time

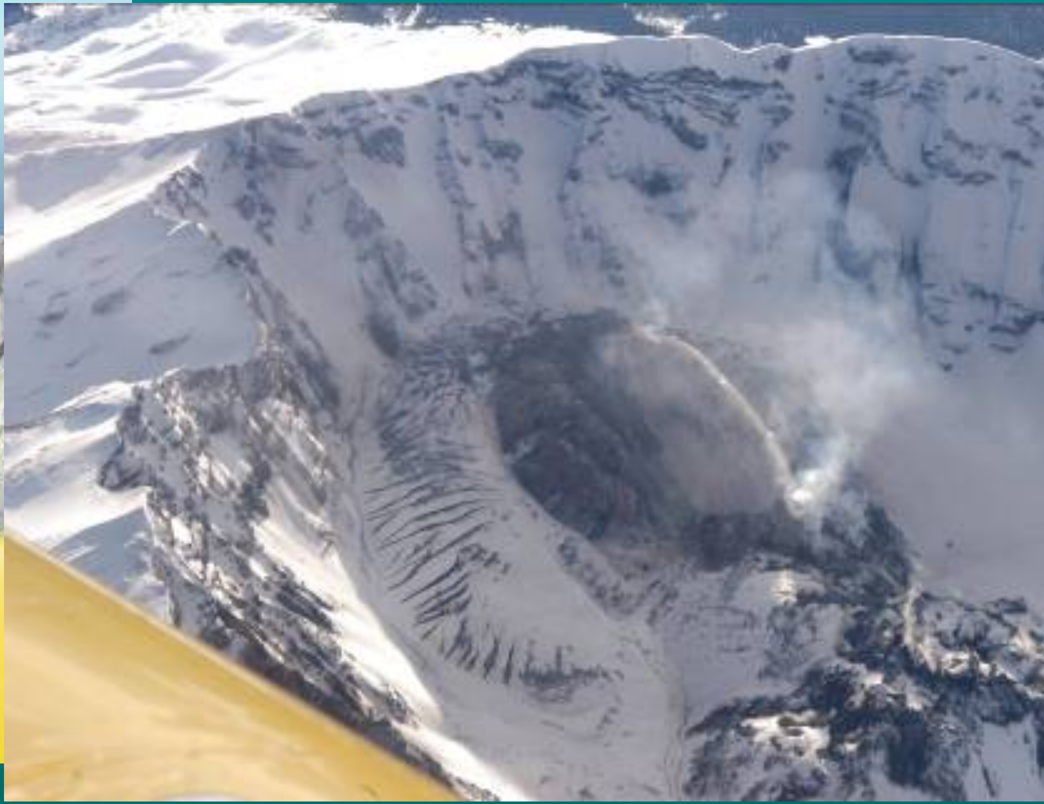



NORTH
SOUTH
ALTITUDE, METERS
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
N
LINE OF SECTION
S
2004 lava flow
2004 intrusive neck
1980-86 dome
Pre-dome bedrock
Earthquake hypocenter
NO VERTICAL EXAGGERATION

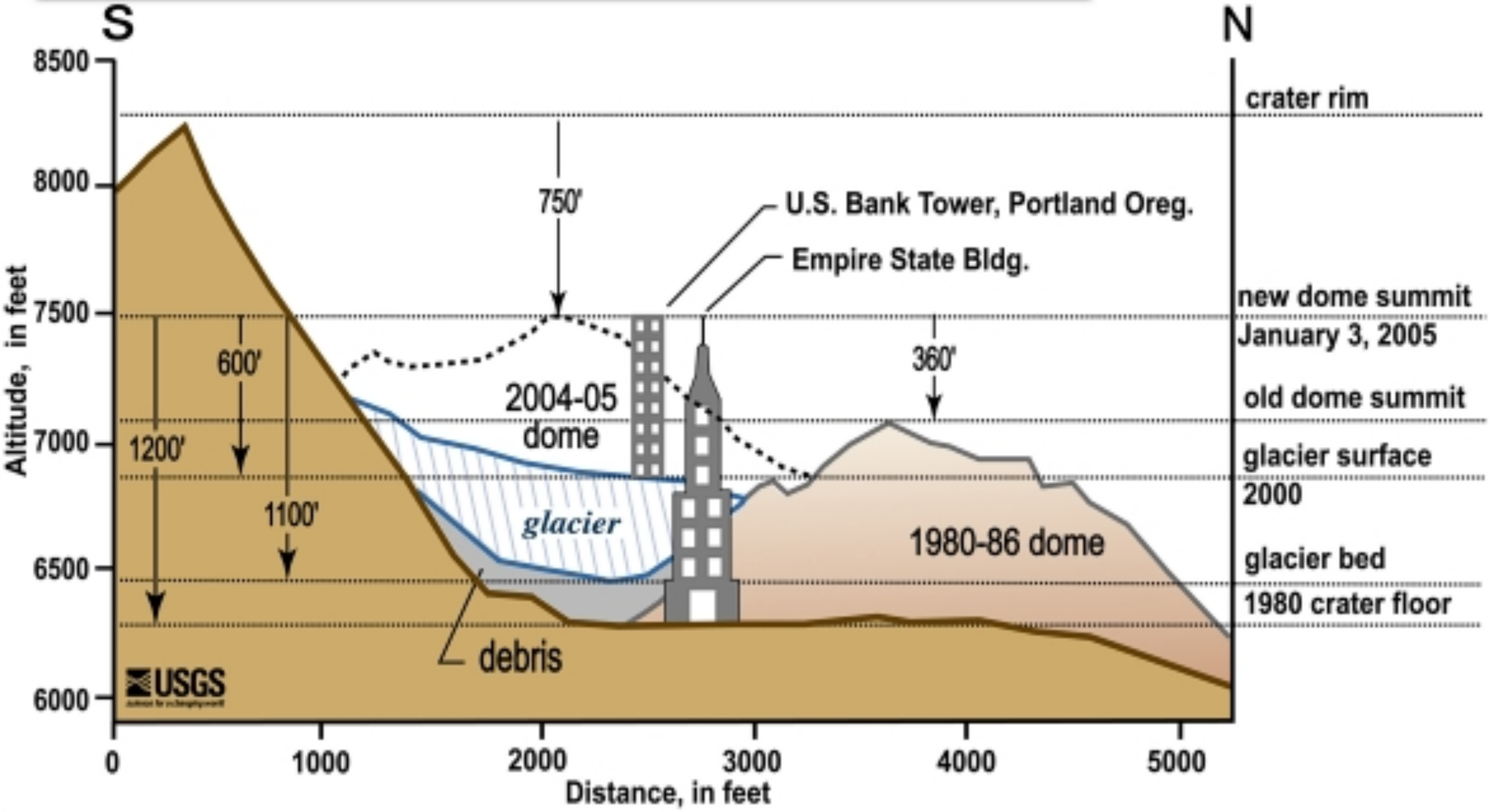
June 23, 2004

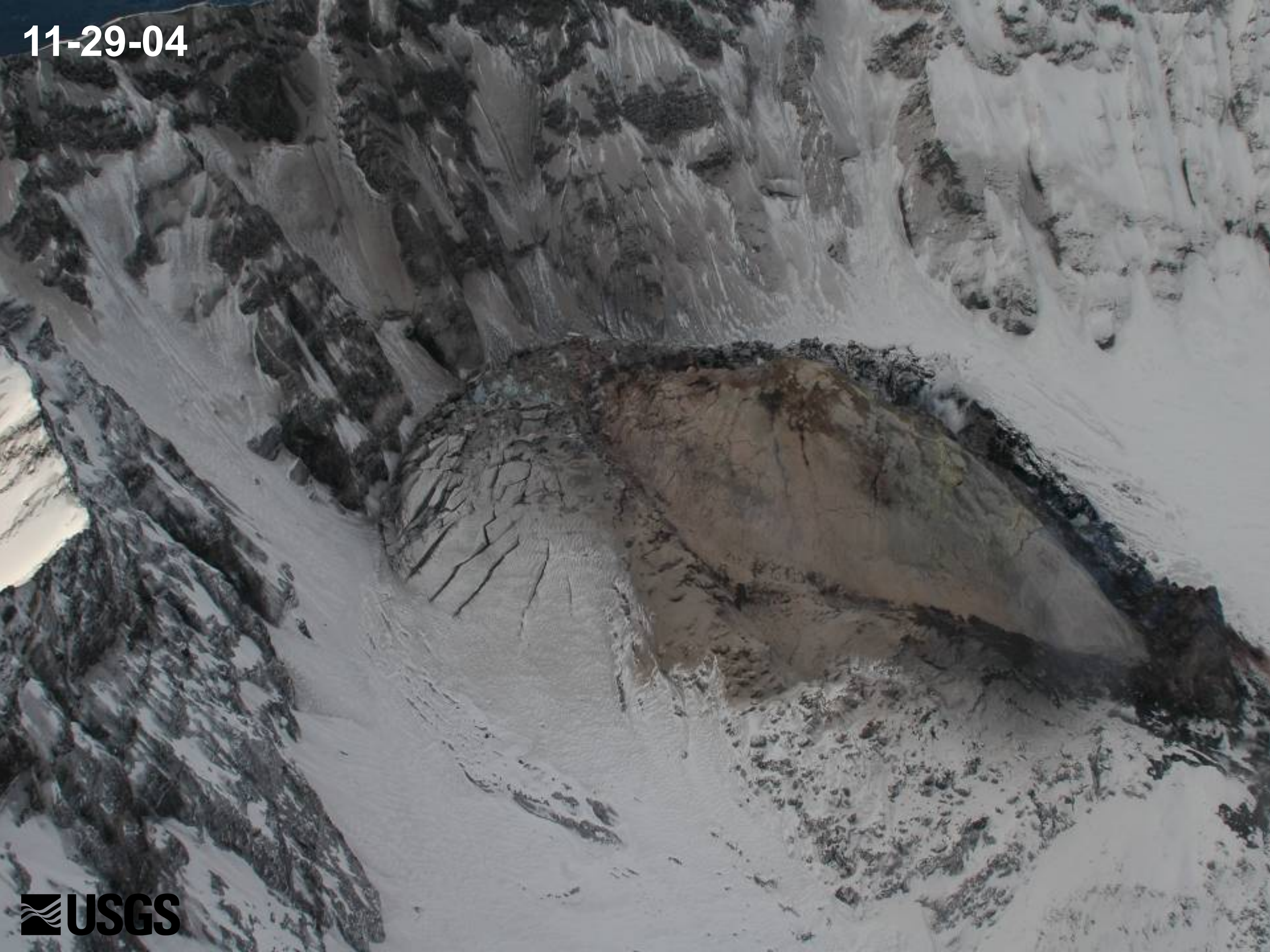


Feb 1, 2005



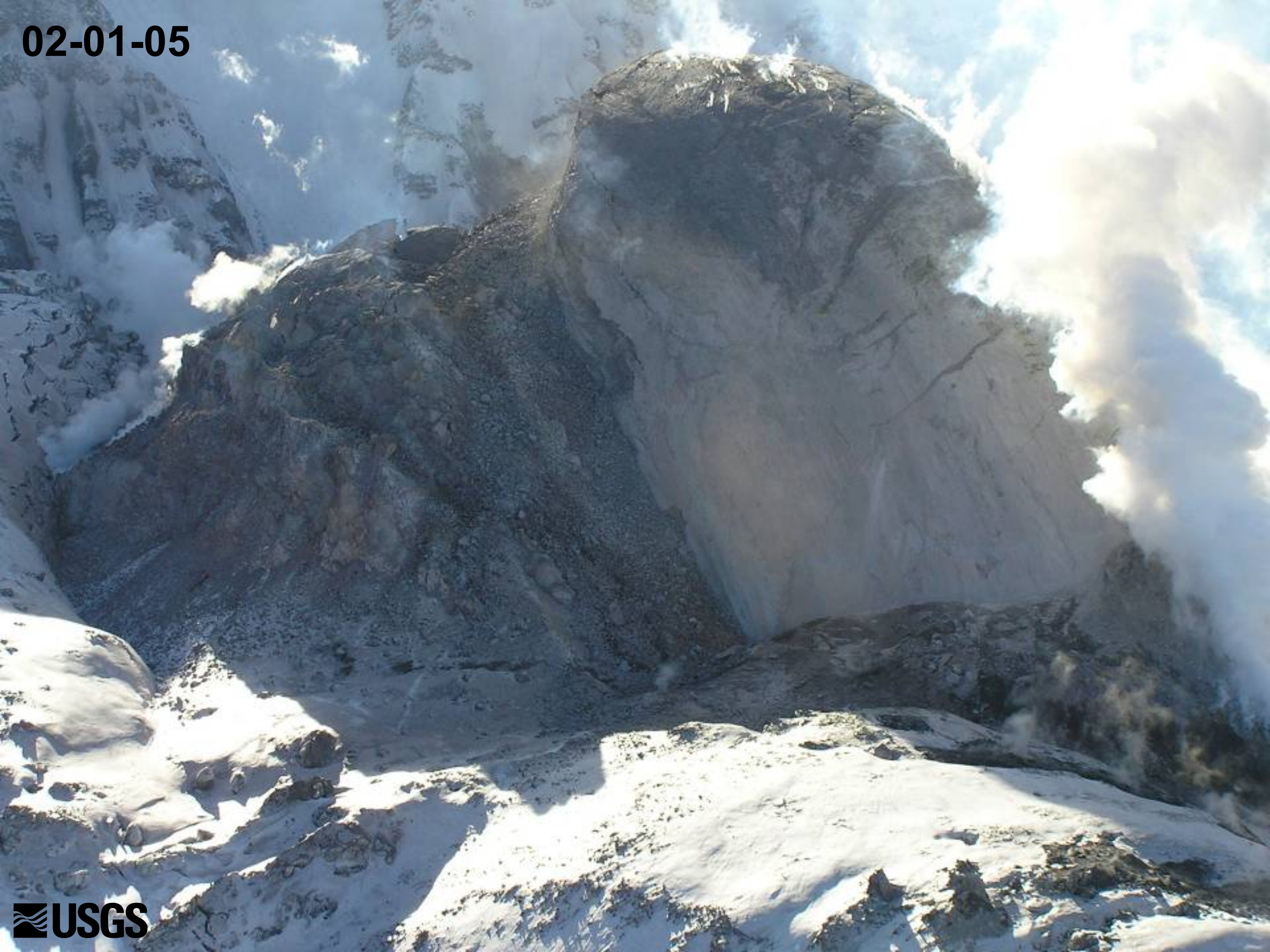
Profile of Crater Features from 1980 to 2005





11-29-04

01-21-05

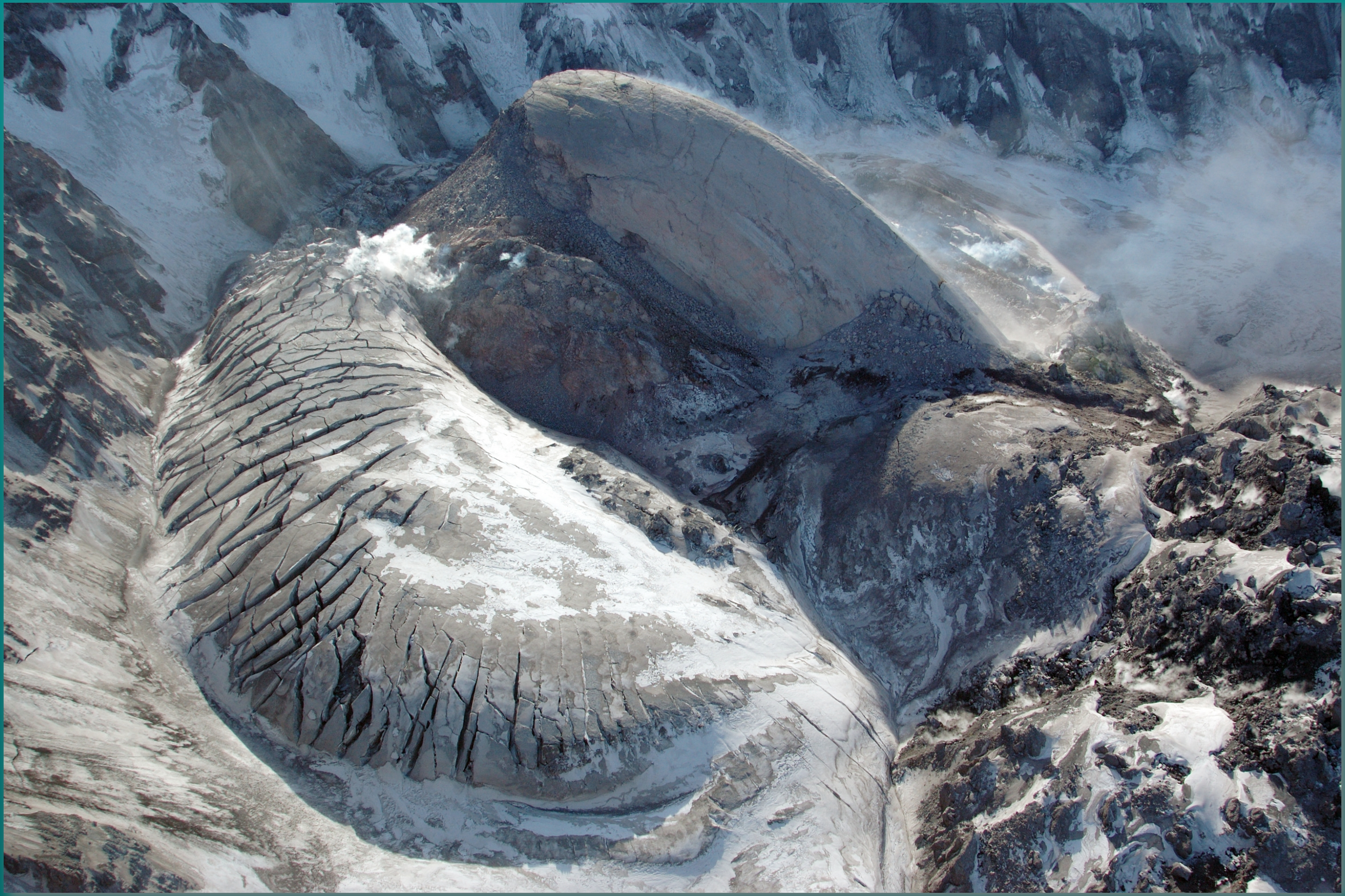


02-01-05

02-01-05

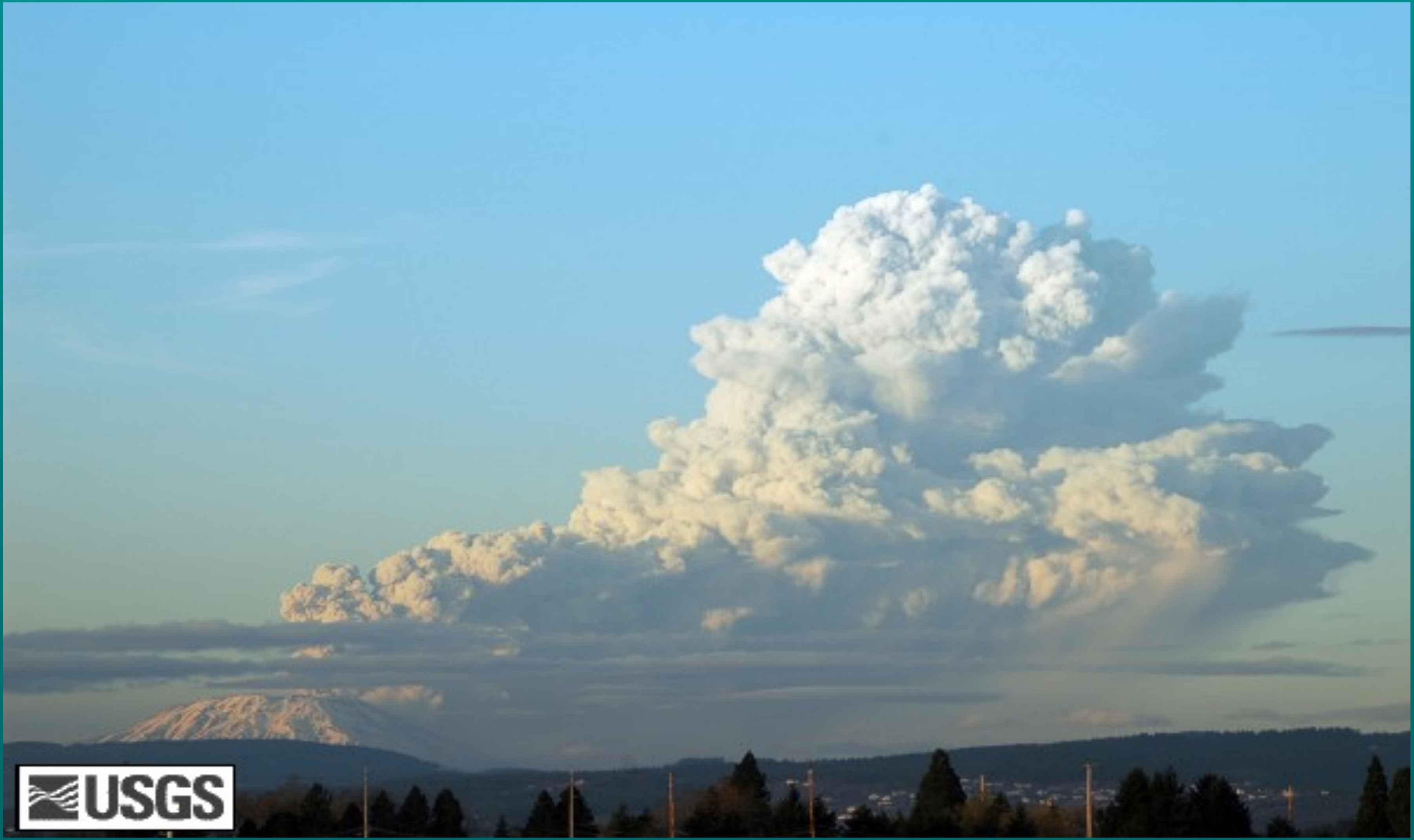
02-01-05

Present configuration of Lava Dome and Deformed Glacier

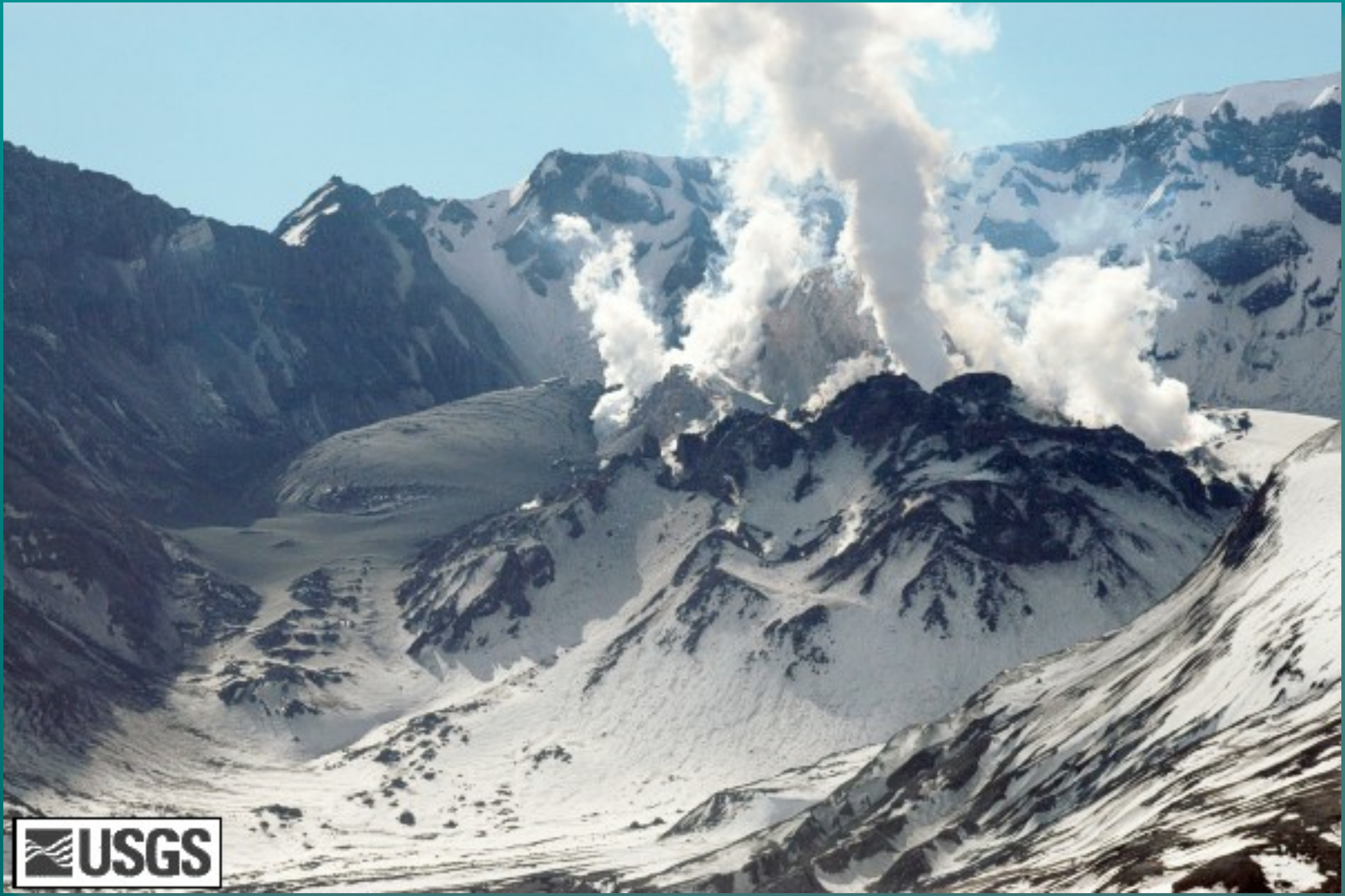


01-17-05

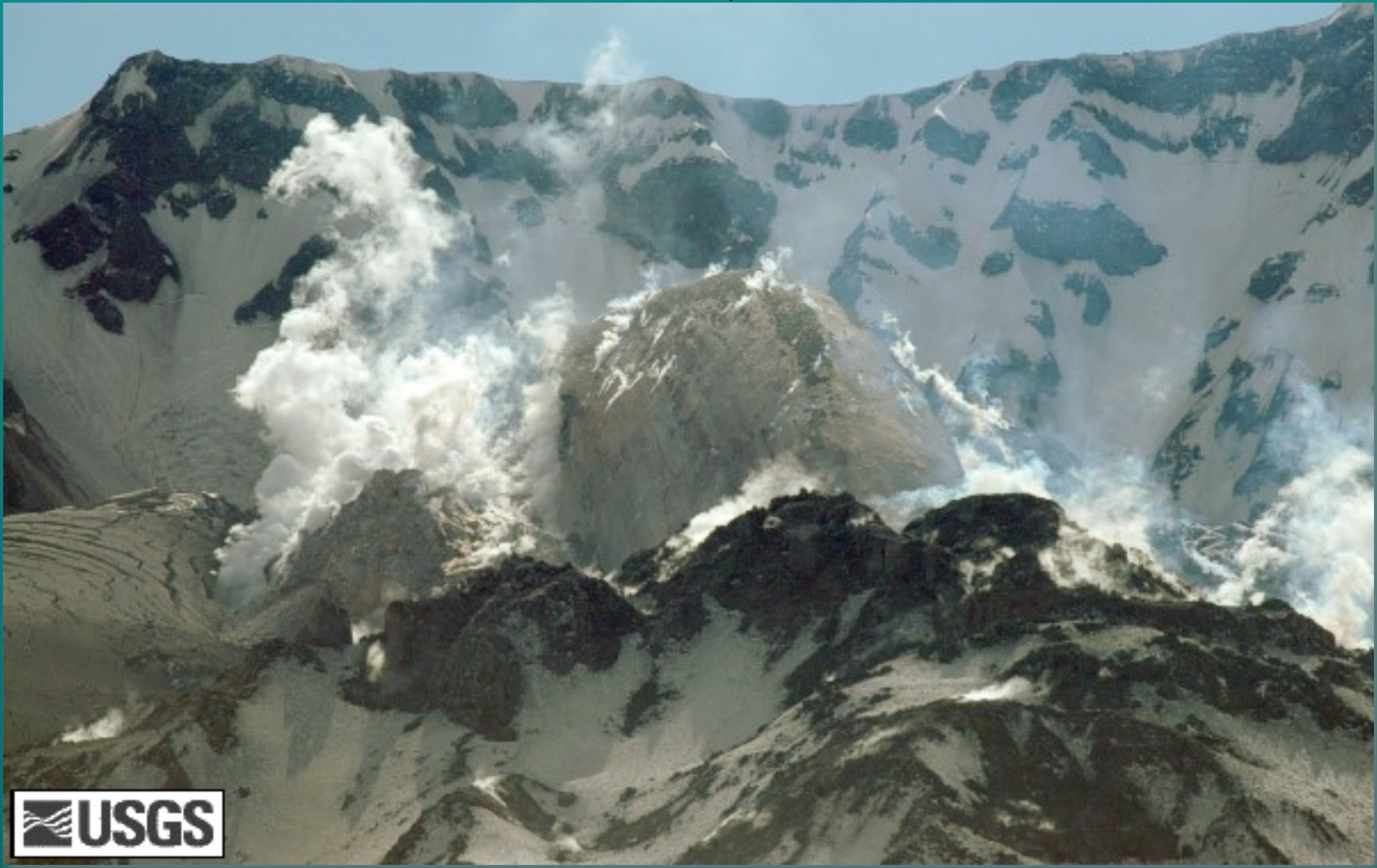
March 8 2005 eruption has seen from USGS--Cascades Volcano Observatory, 5:30pm Vancouver WA



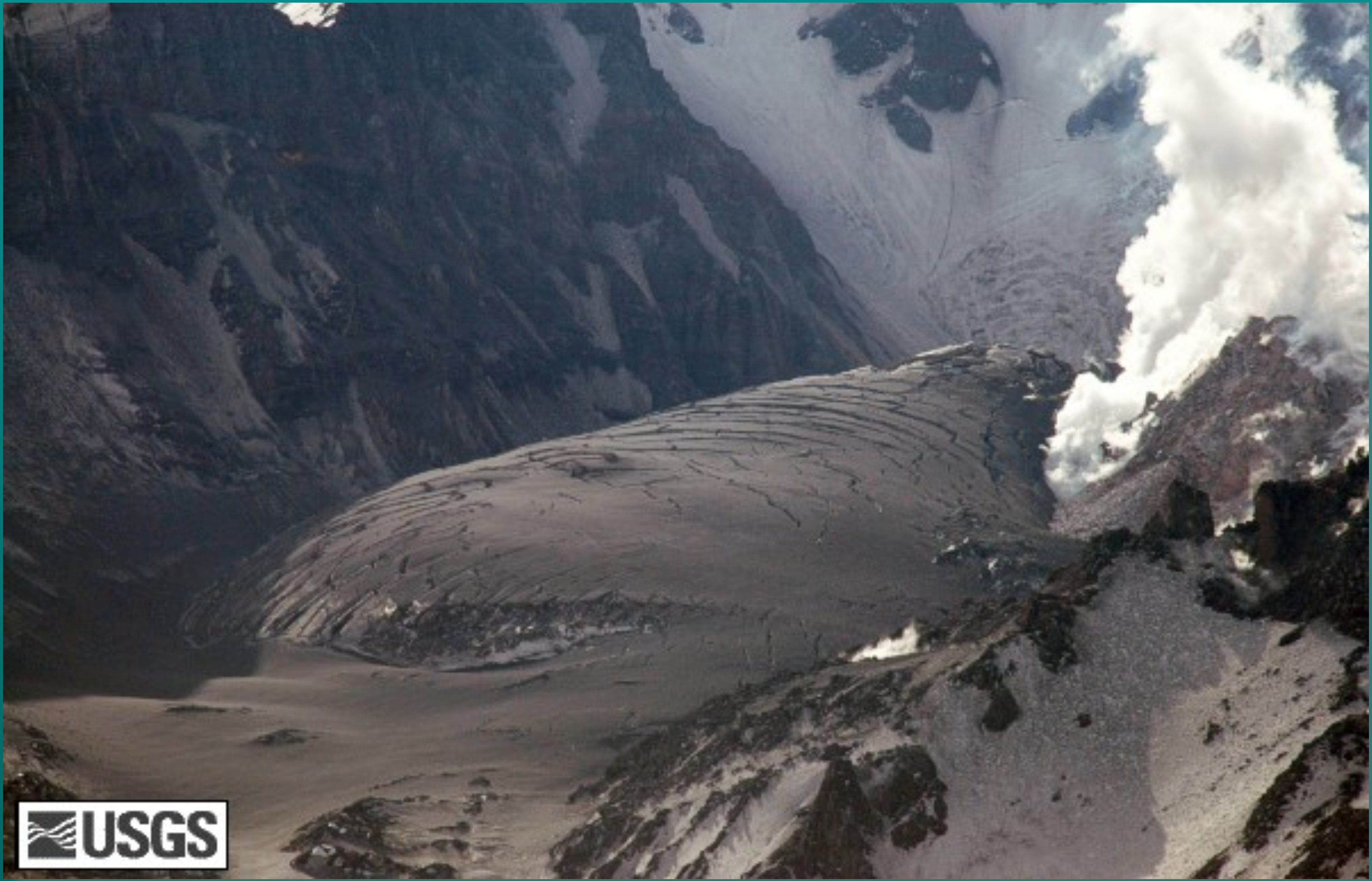
Old and New Domes March 9, 2005



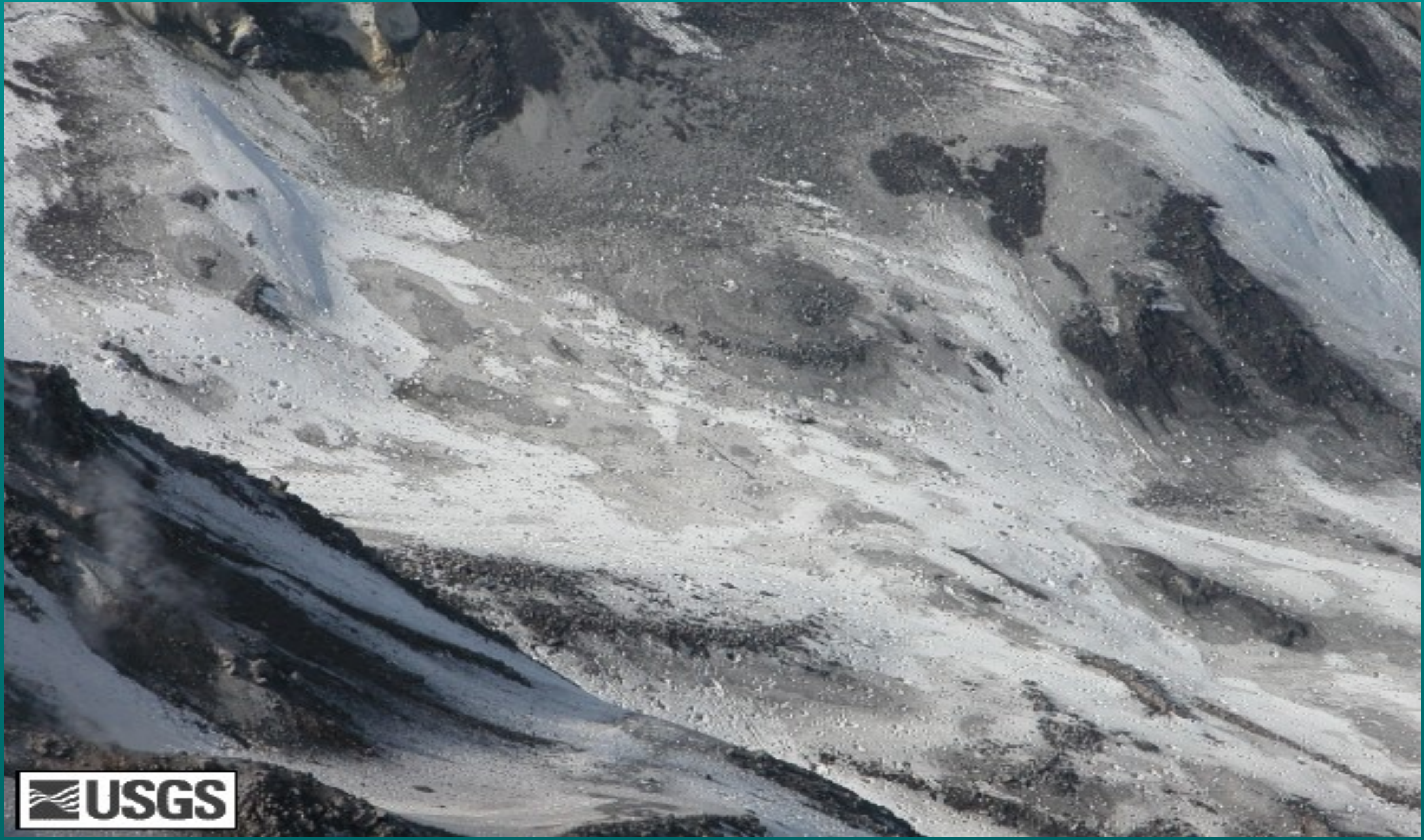
“Whaleback” 2004-05 lava dome
March 9, 2005



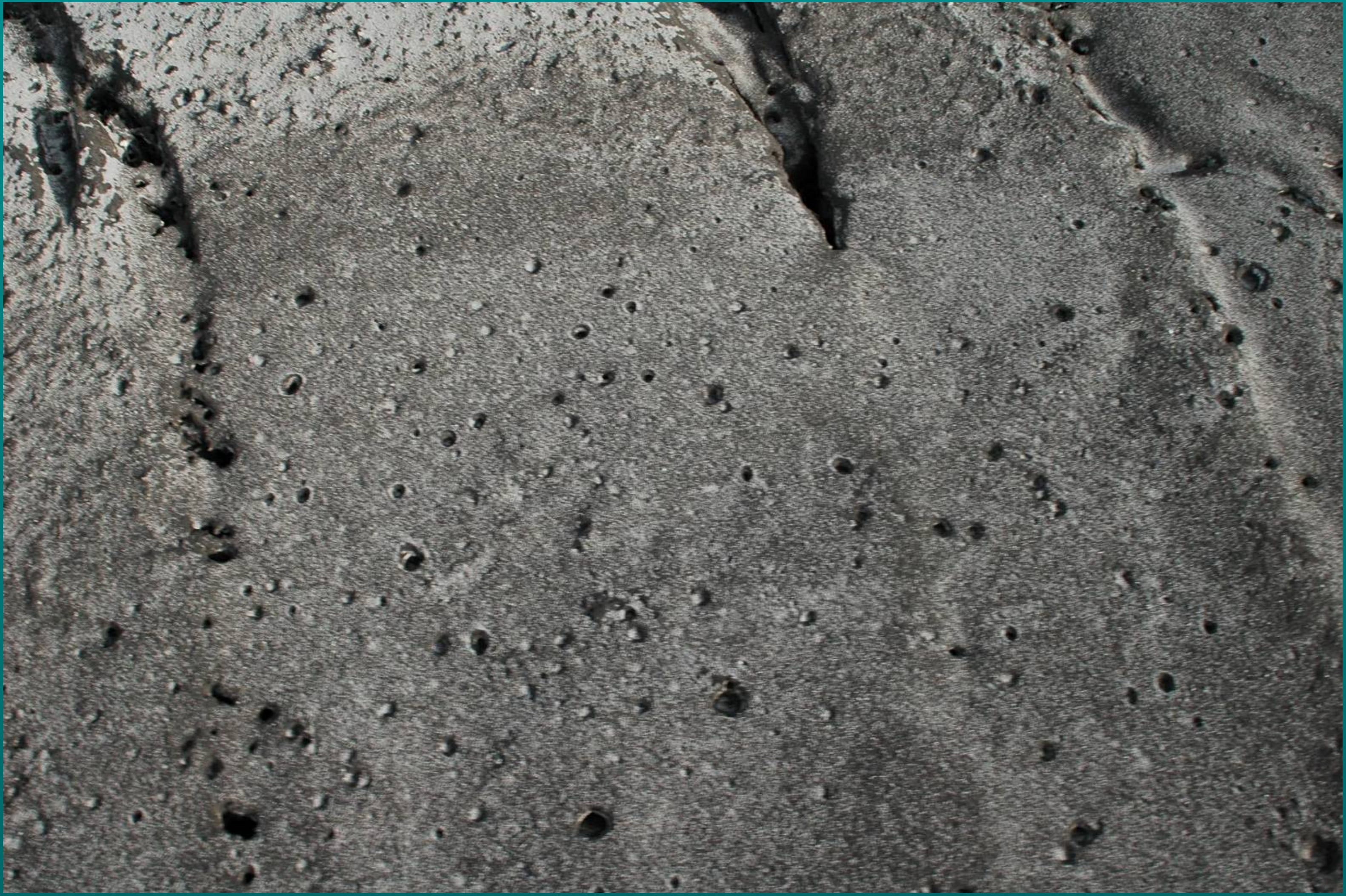
Ash-covered glacier ice March 9, 2005



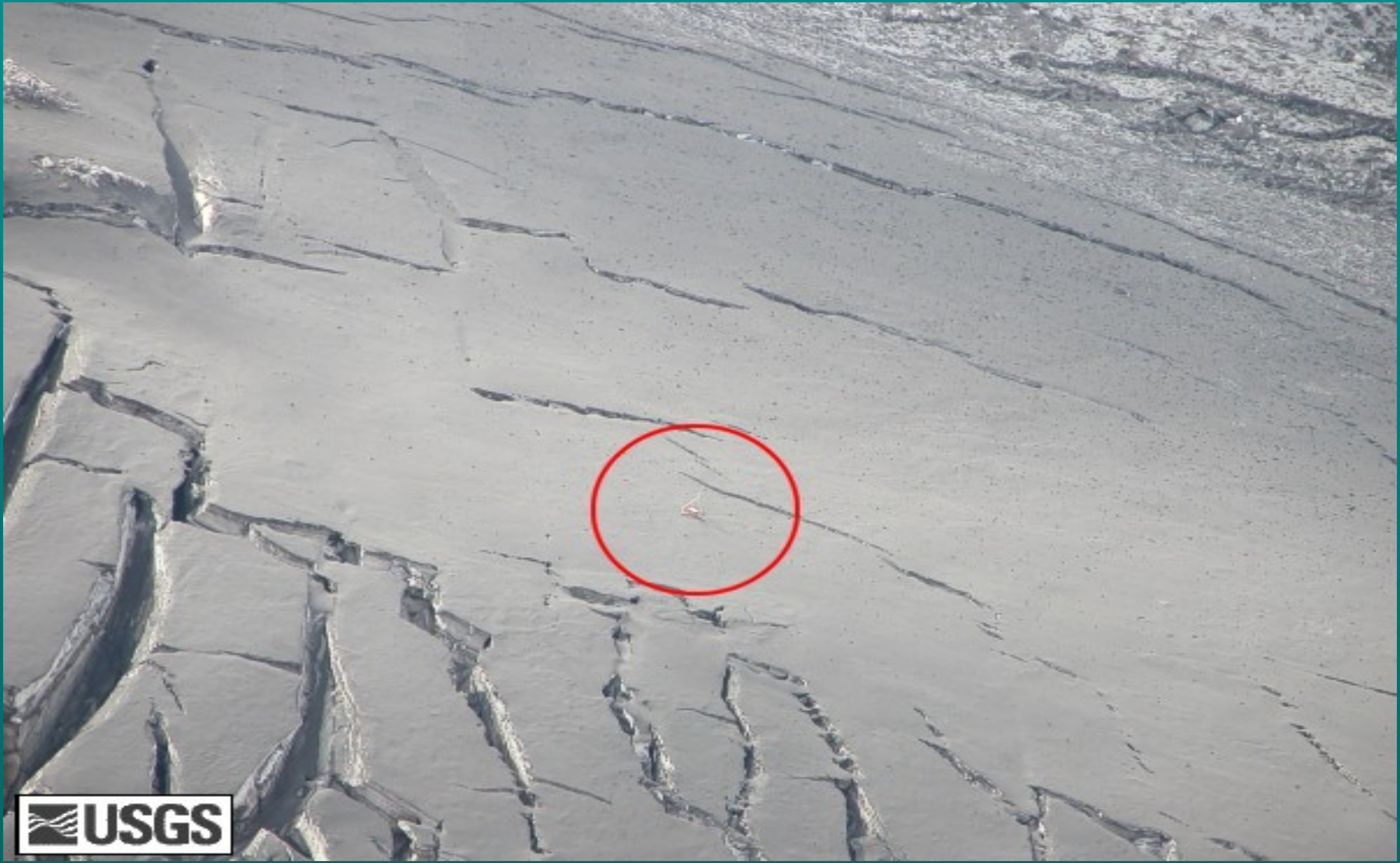
Ballistic "craters" from the event of March 8, 2005. The largest ballistic impact crater seen was estimated to be about 1 meter across.   March 9, 2005



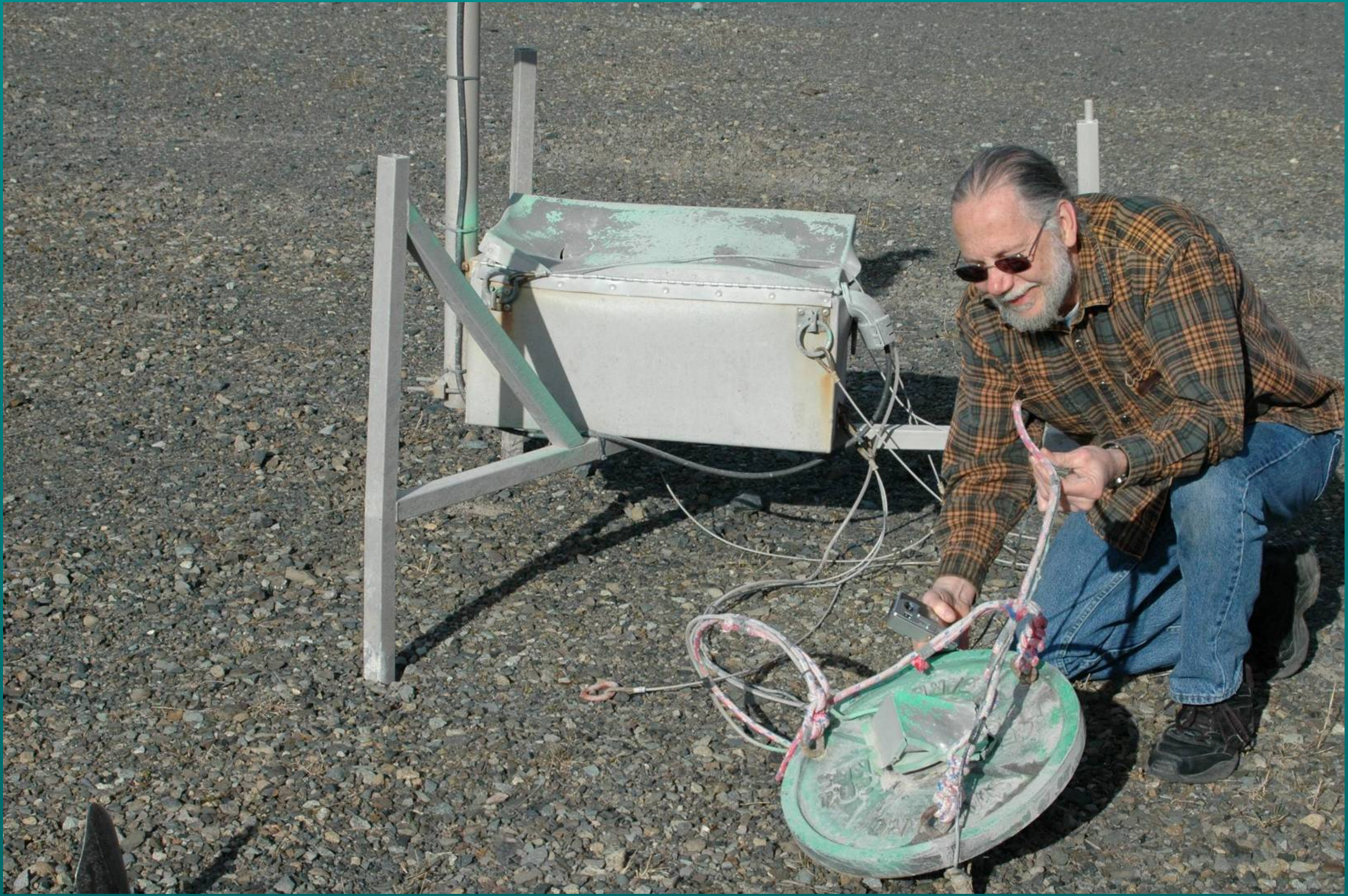
Close-up view of Ballistic Impacts on Glacier, Eruption of March 8, 2005



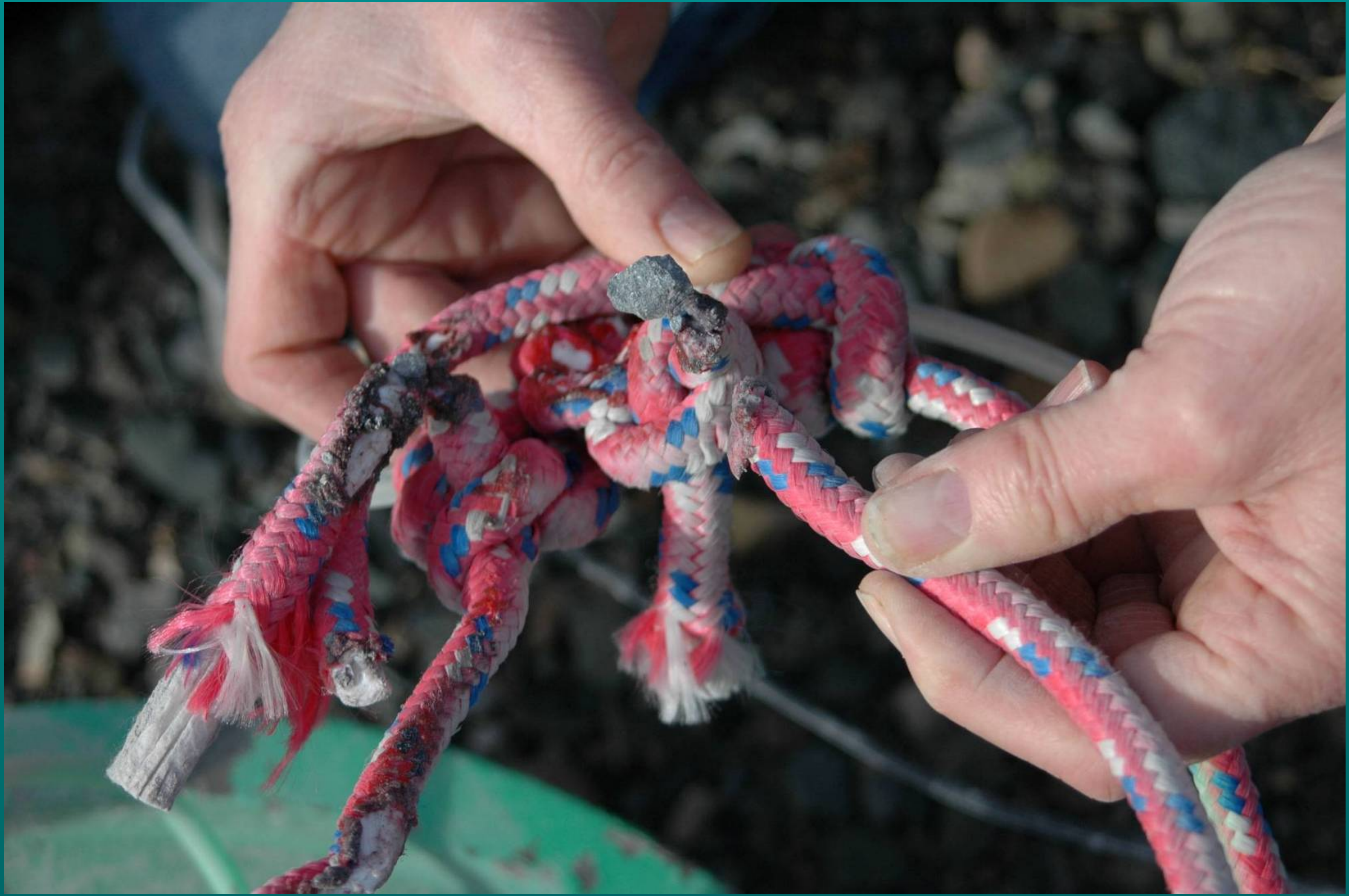
Station "ICY5"on eastside glacier
March 9, 2005



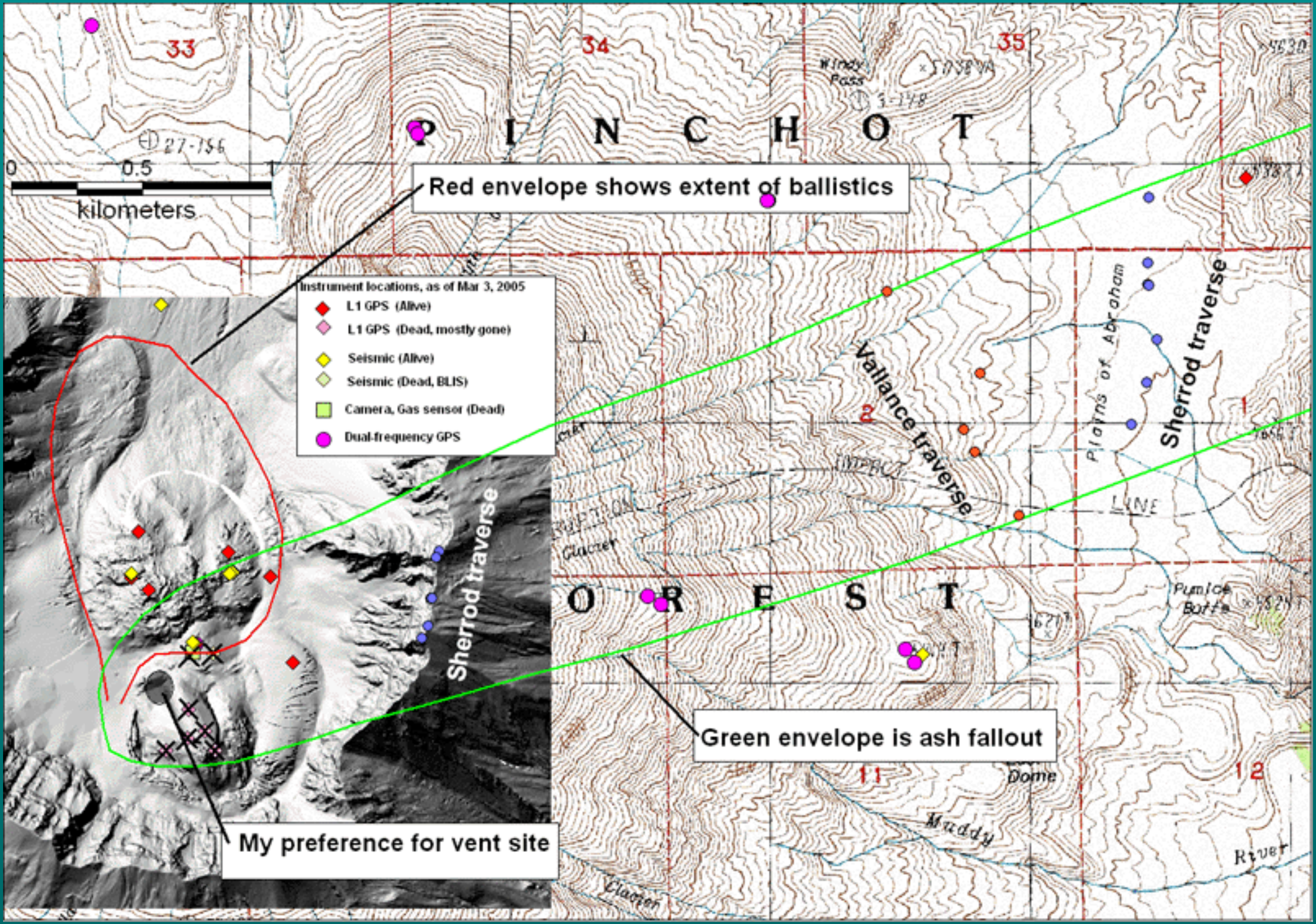
Eruption-damaged Seismic Station from northeast dome, Eruption of March 8, 2005



Melted Nylon Rope and Attached Lava Rock from Northeast Dome Station



Preliminary Distribution Map of Ash Fallout and Ballistics March from 8th Eruption



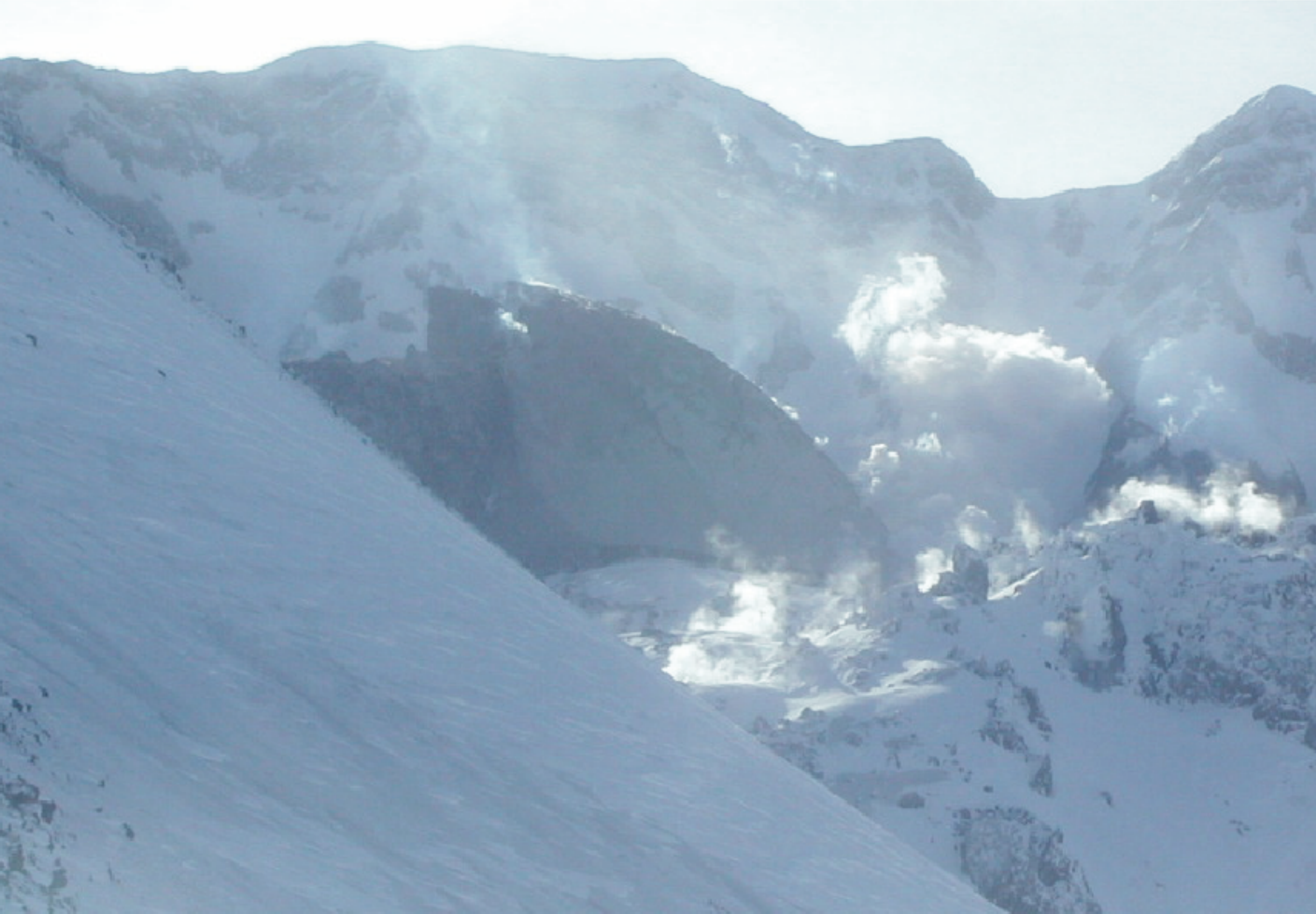
Red envelope shows extent of ballistics

Green envelope is ash fallout

My preference for vent site

Oct. 10, 2004

January 14, 2005

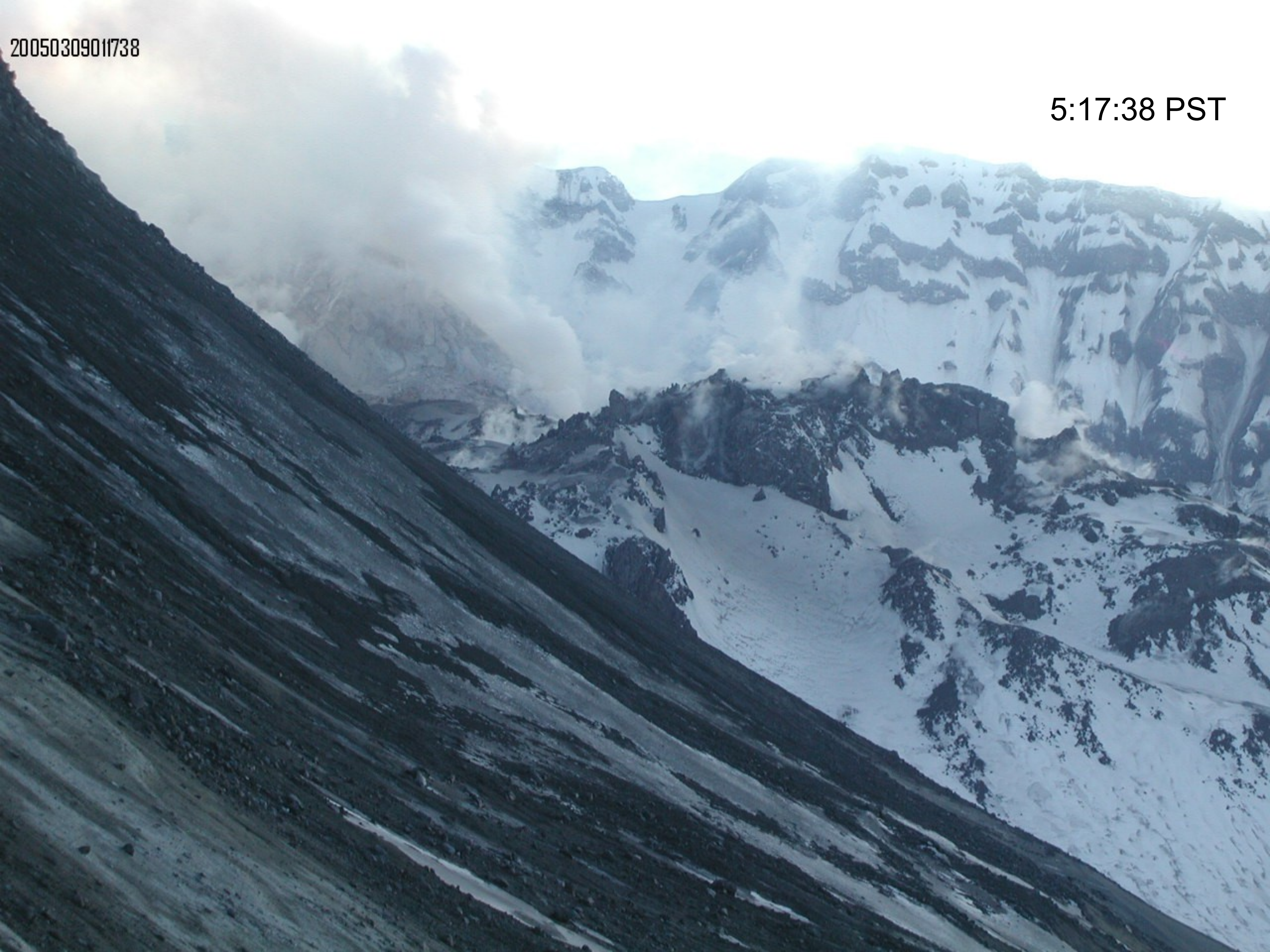


February 1, 2005

Sugar Bowl Dome Camera
March 8 Event Sequence
5:17 – 5:53 pm PST

Note: Ash Eruptions Can Begin Abruptly with Little or No Warning

C. Thornber & the CVO Camera Watchers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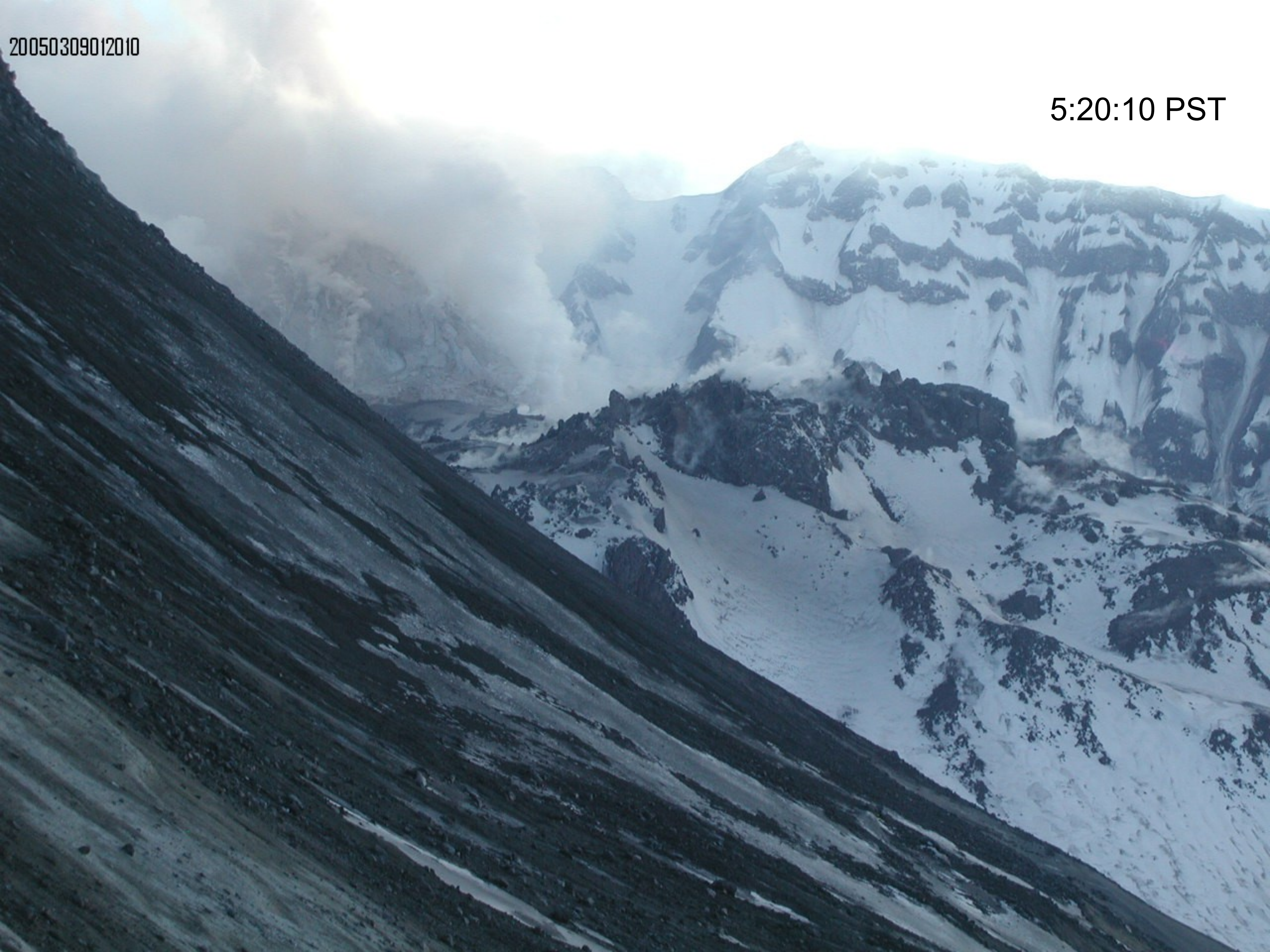
20050309012010
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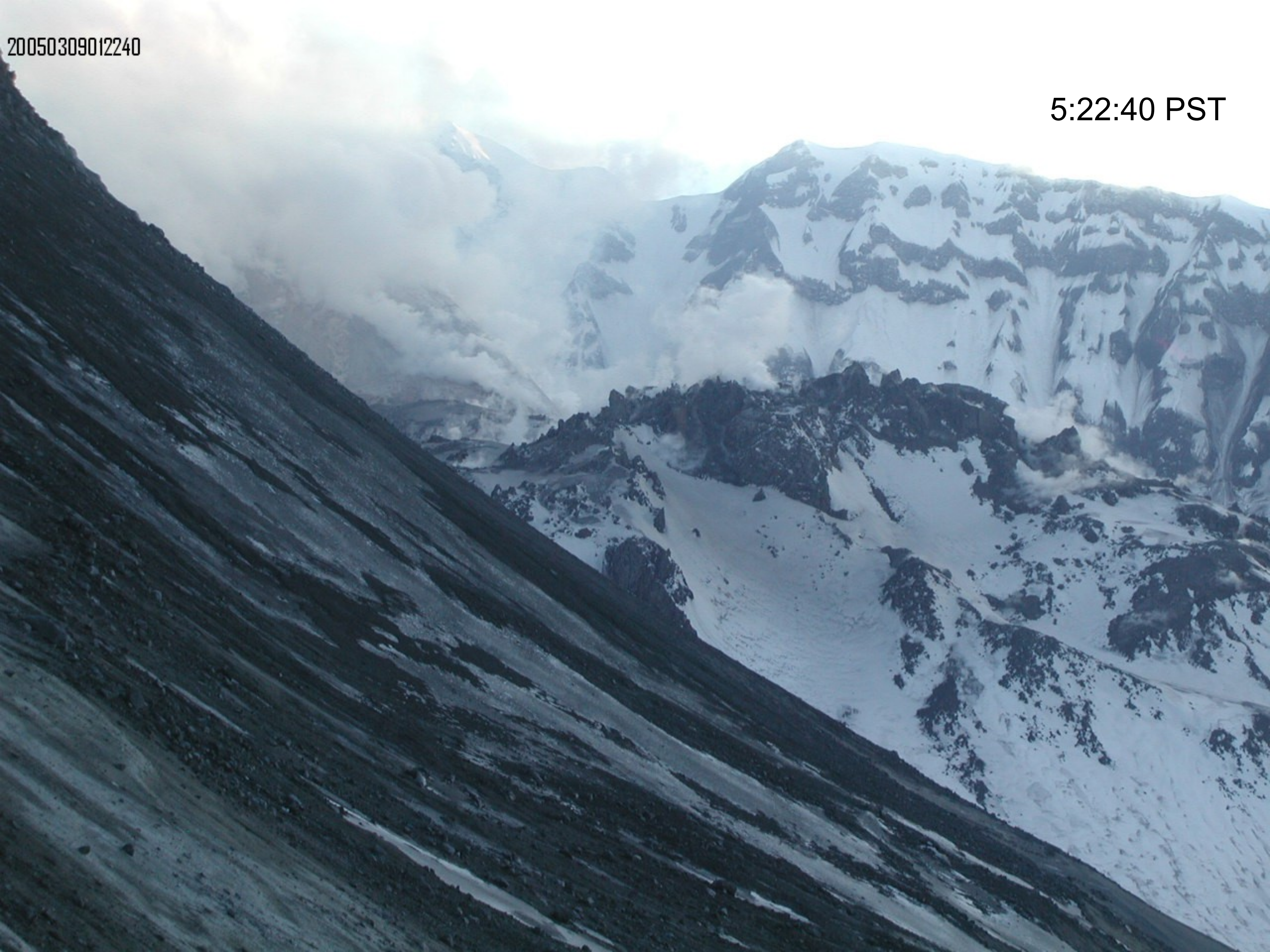

20050309012240
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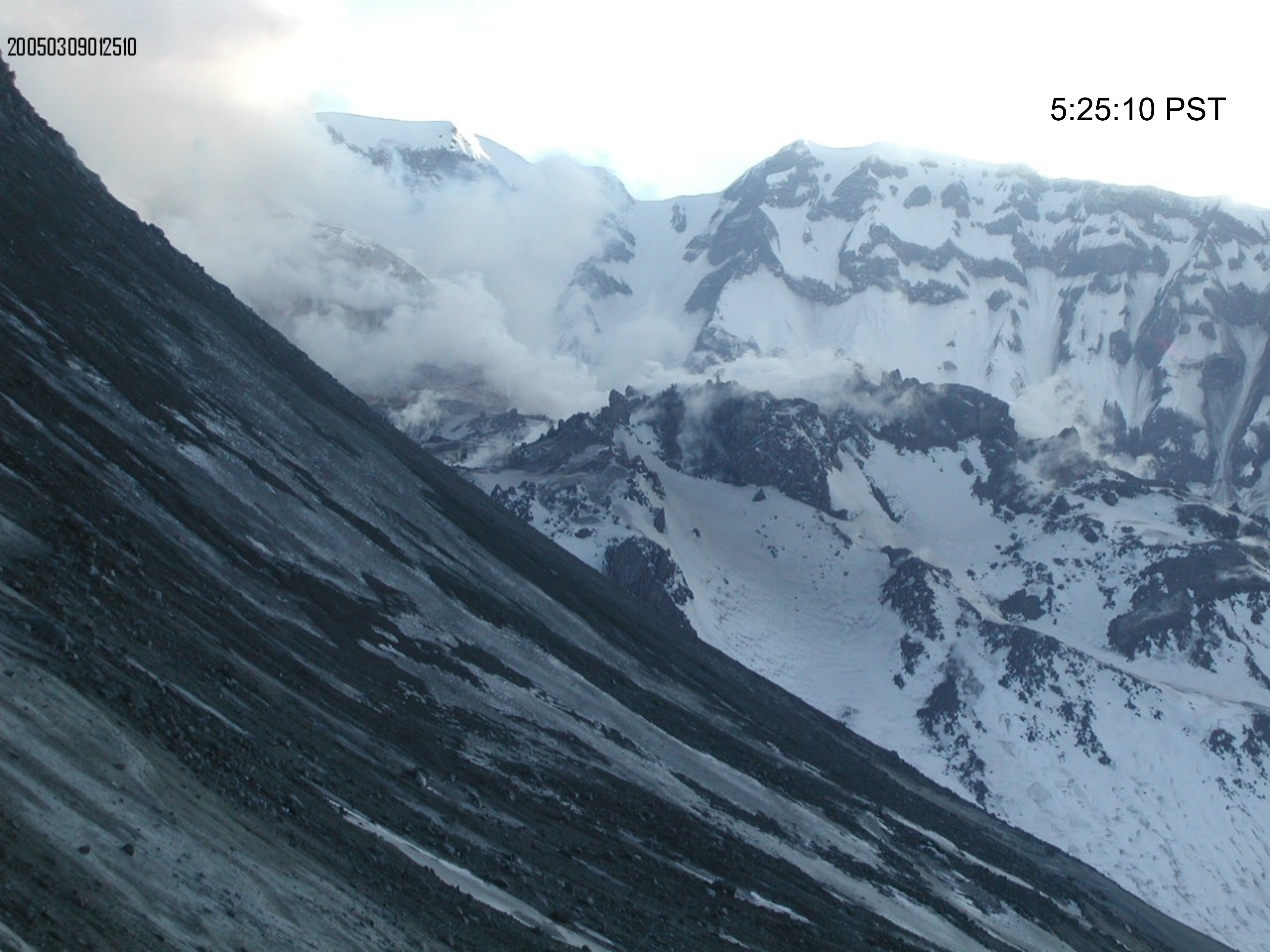
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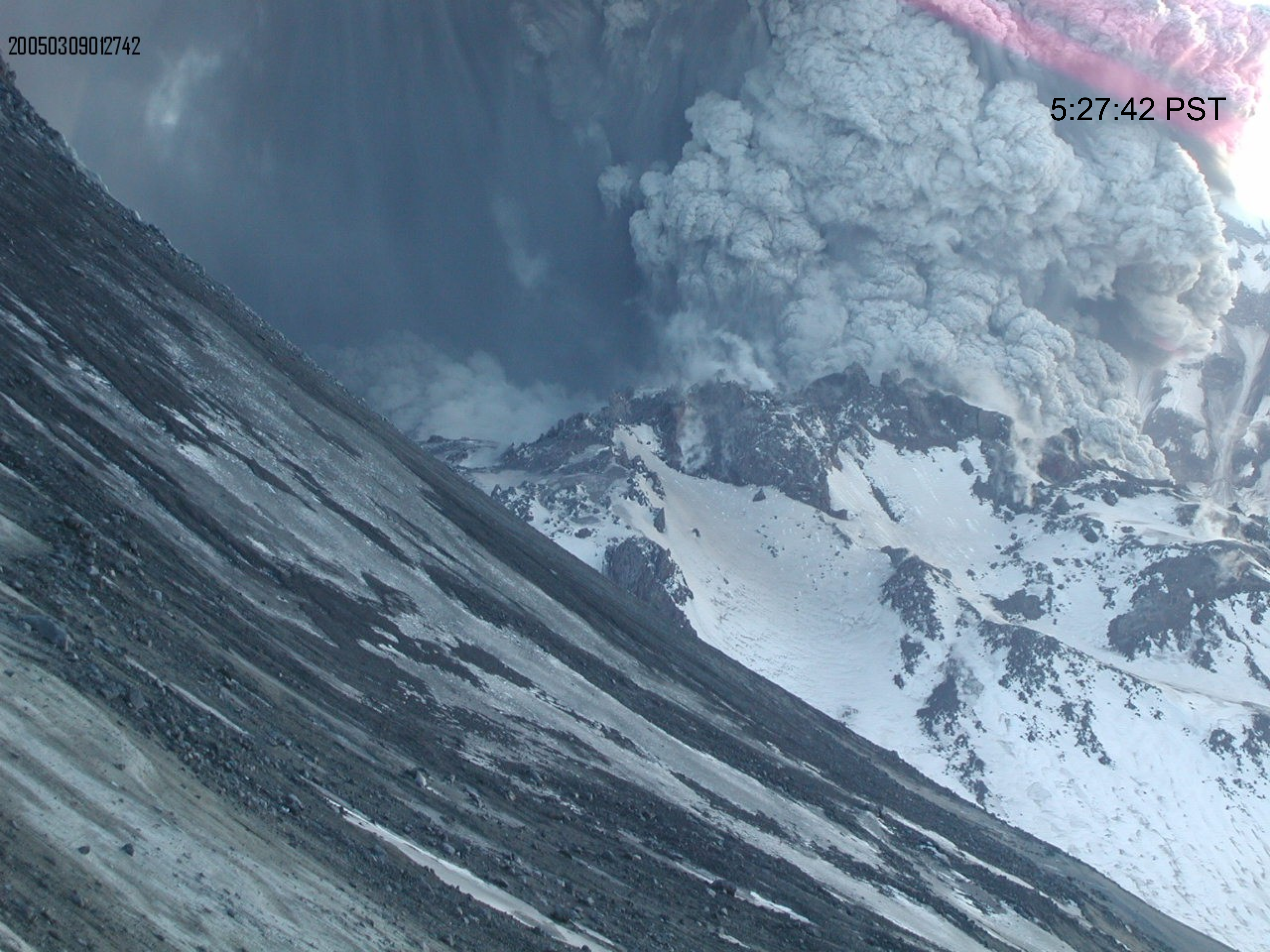
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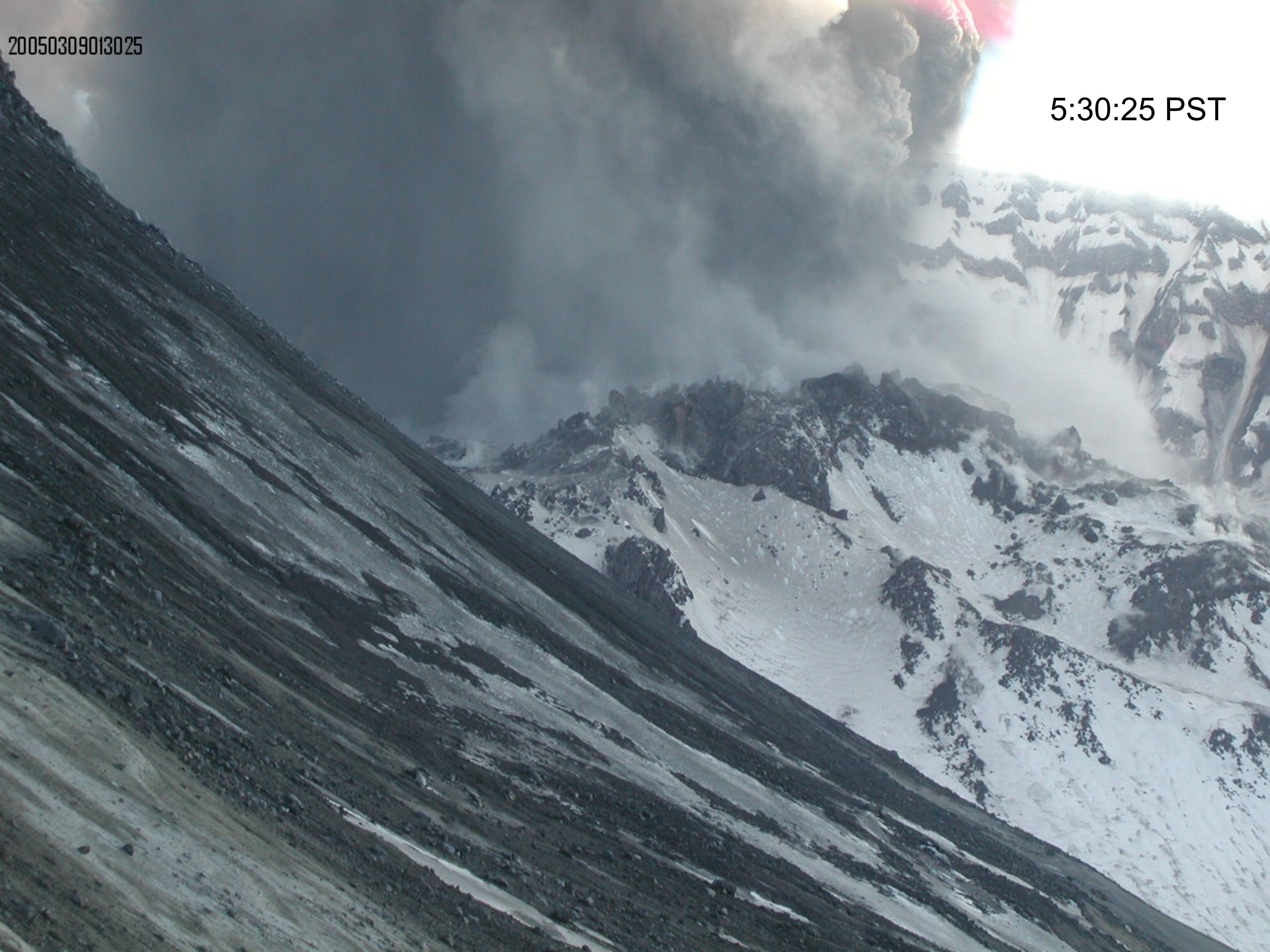

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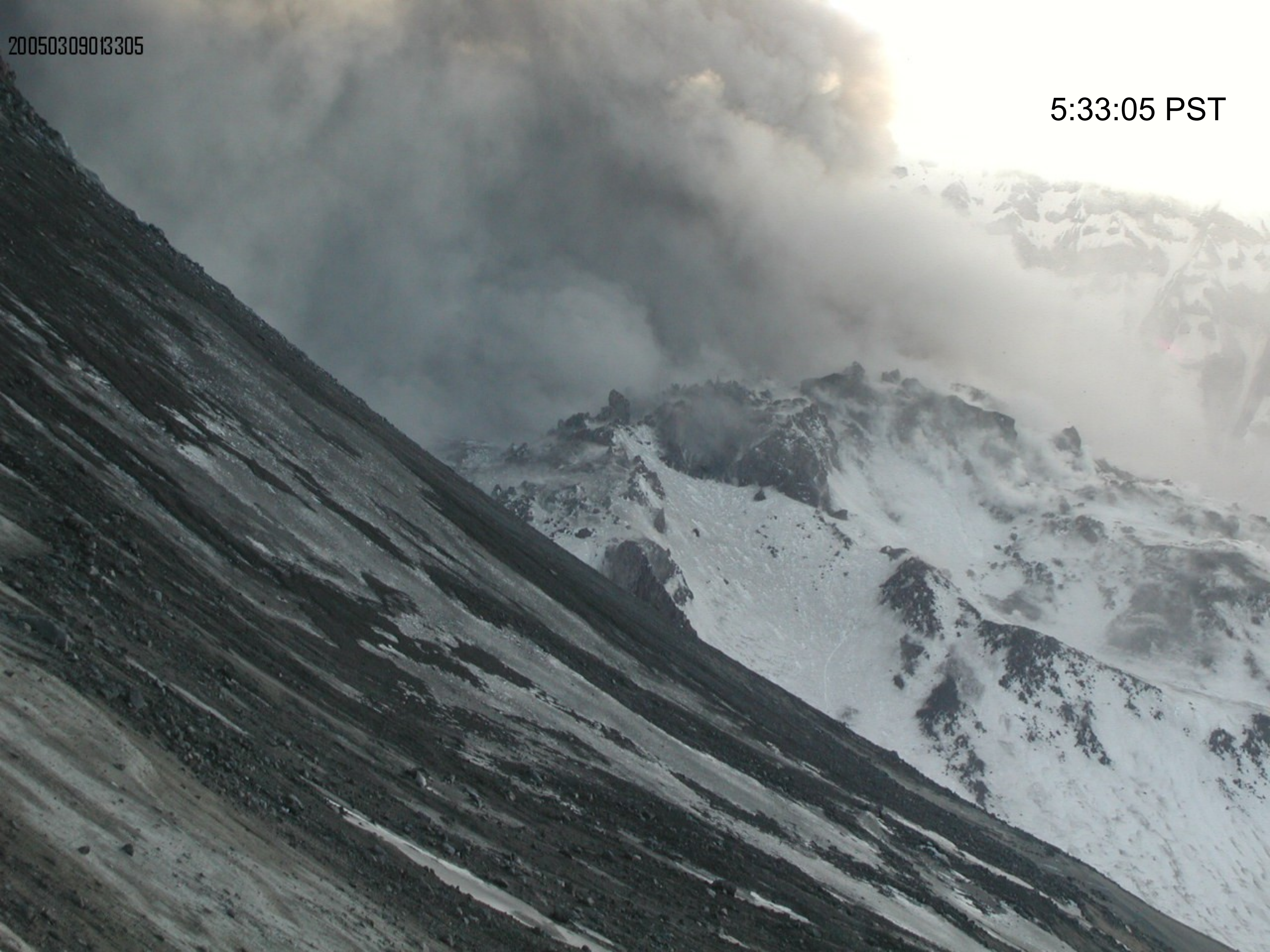
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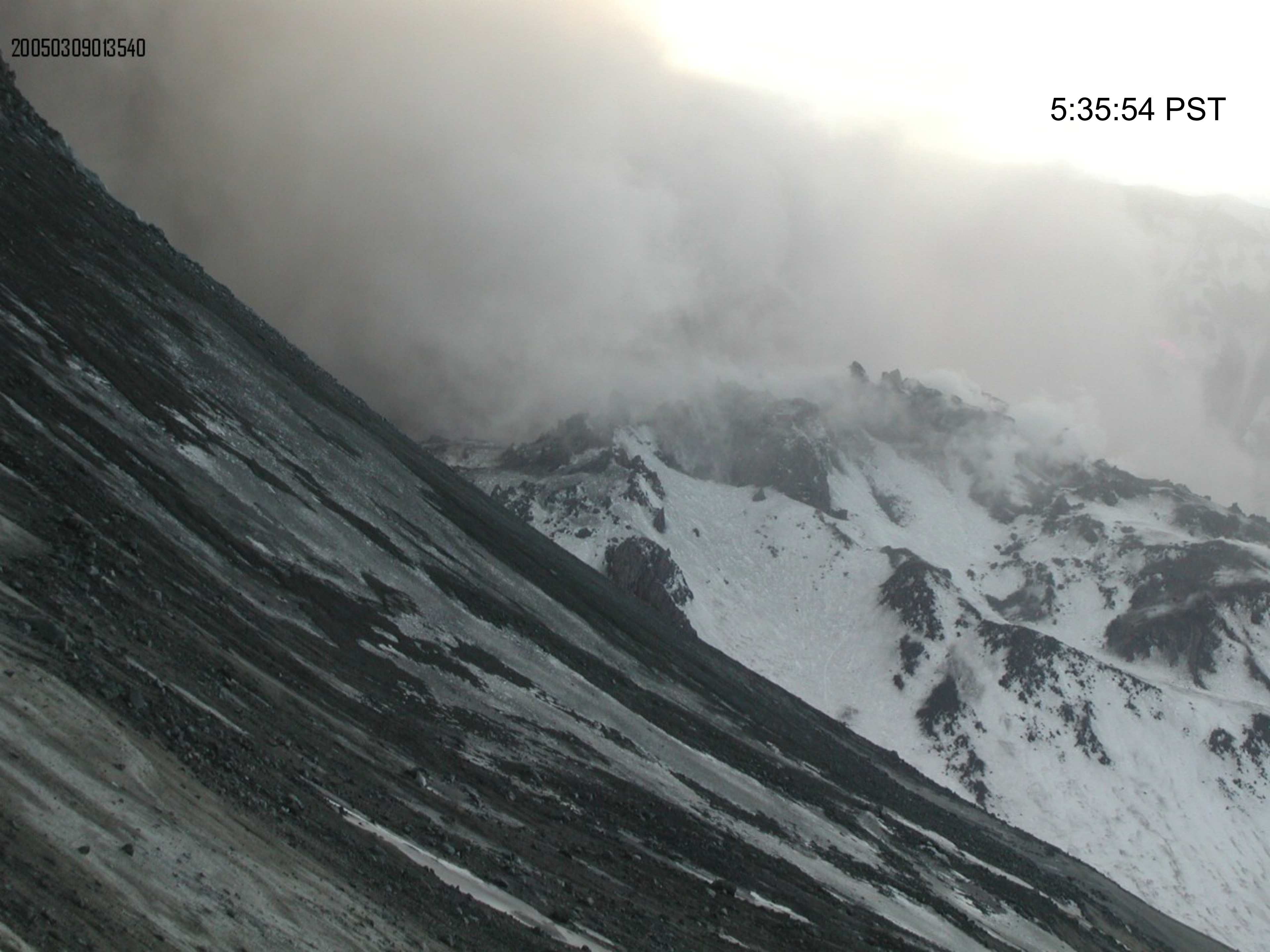
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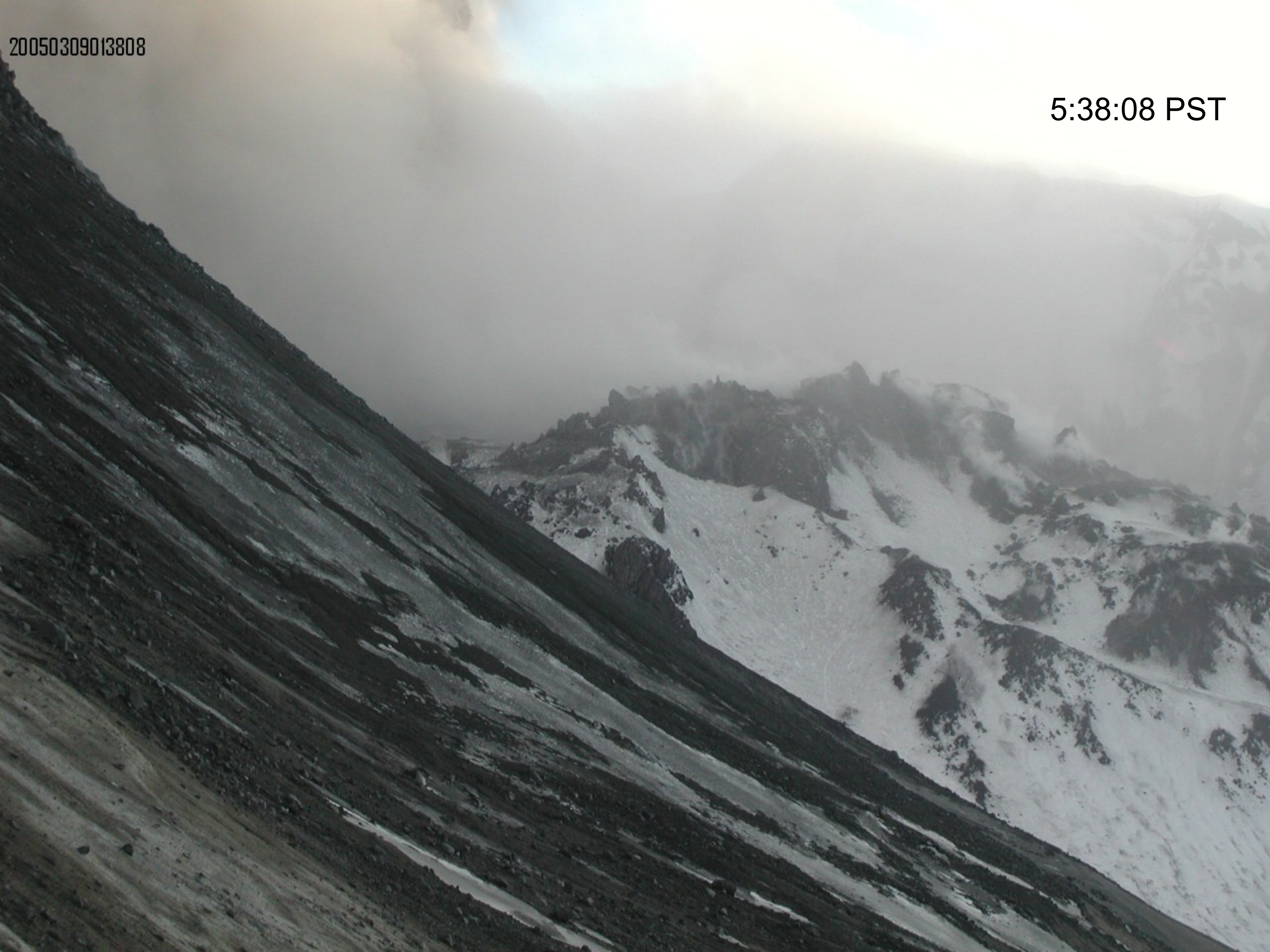
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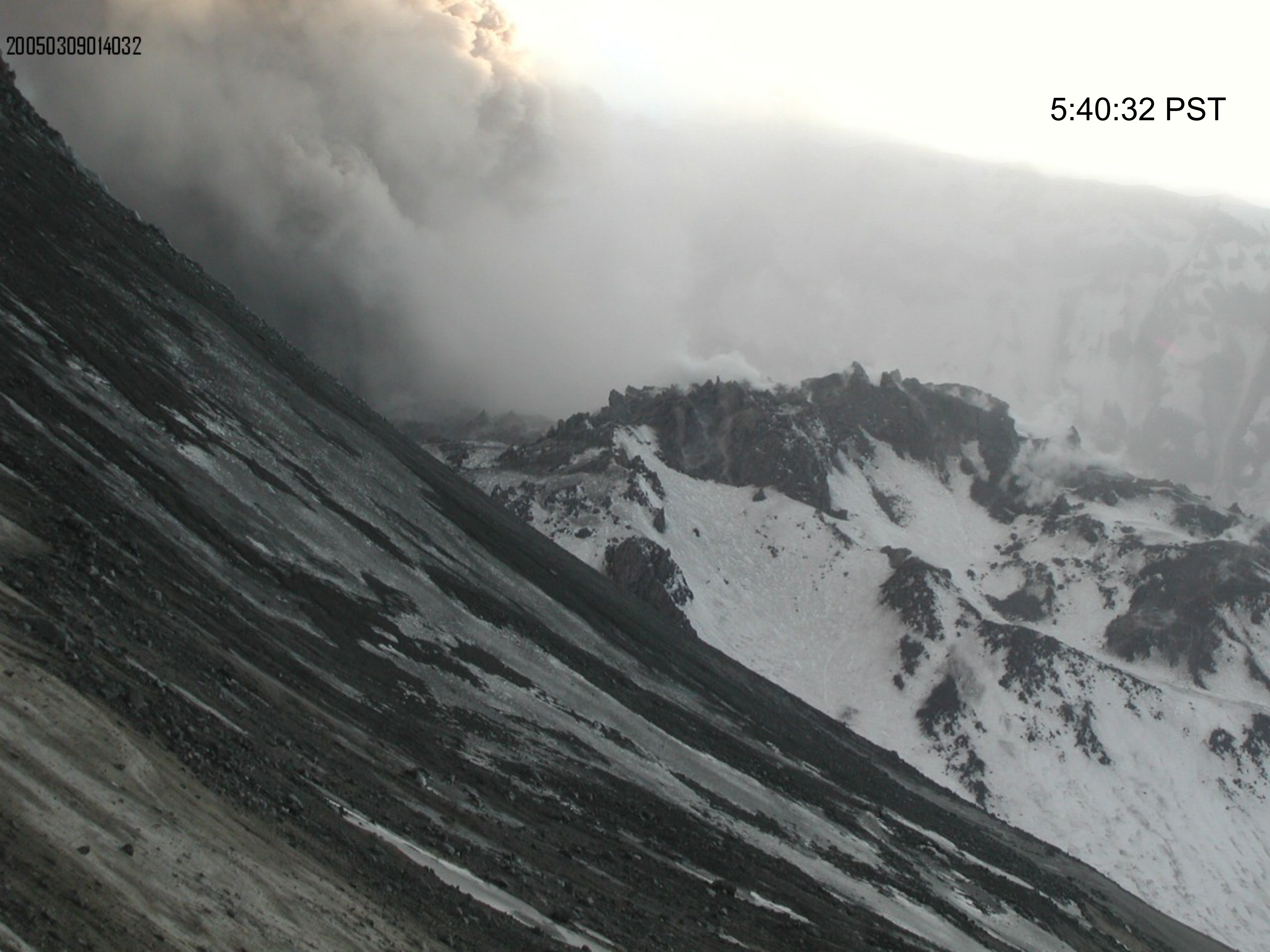
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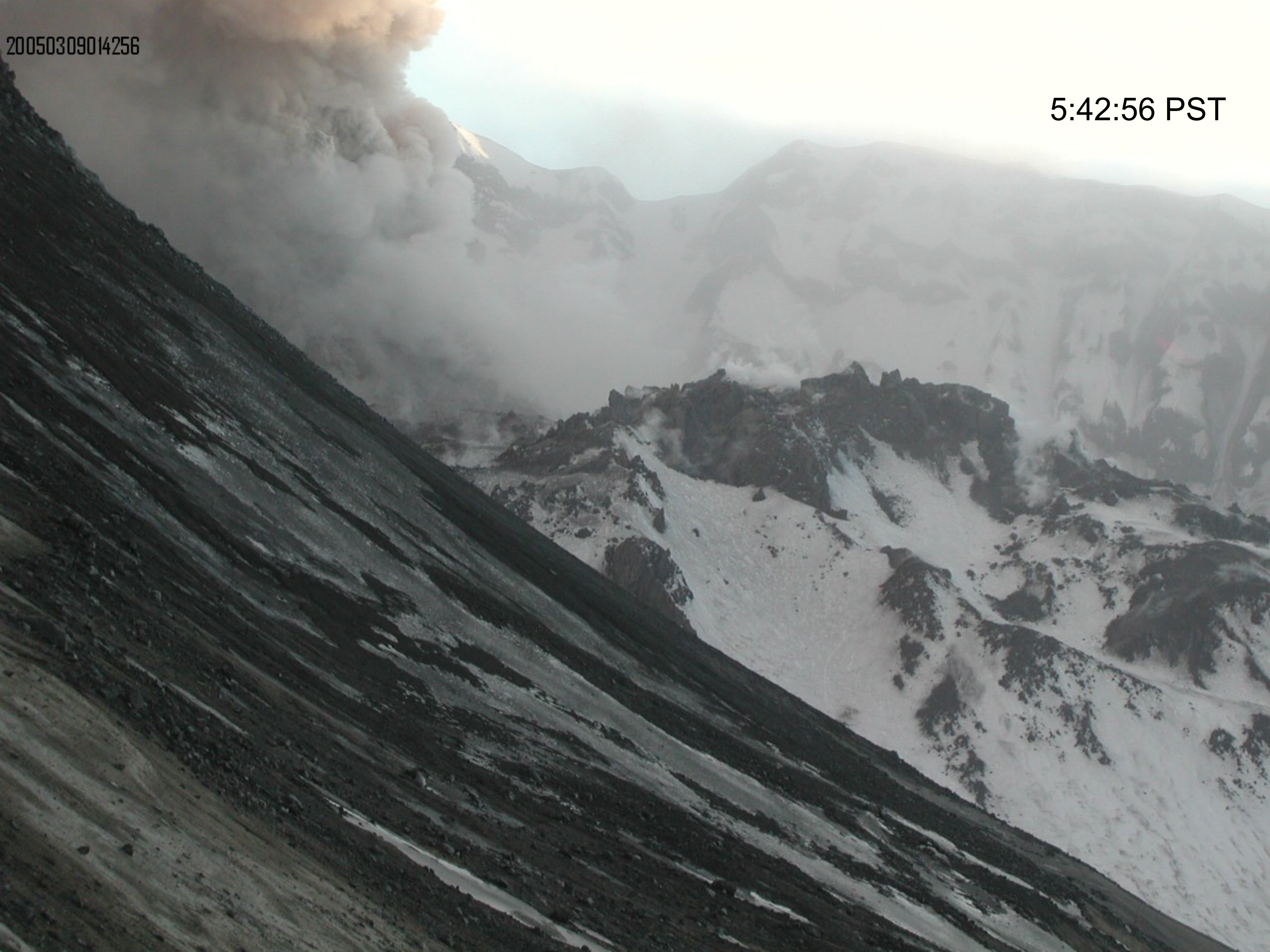
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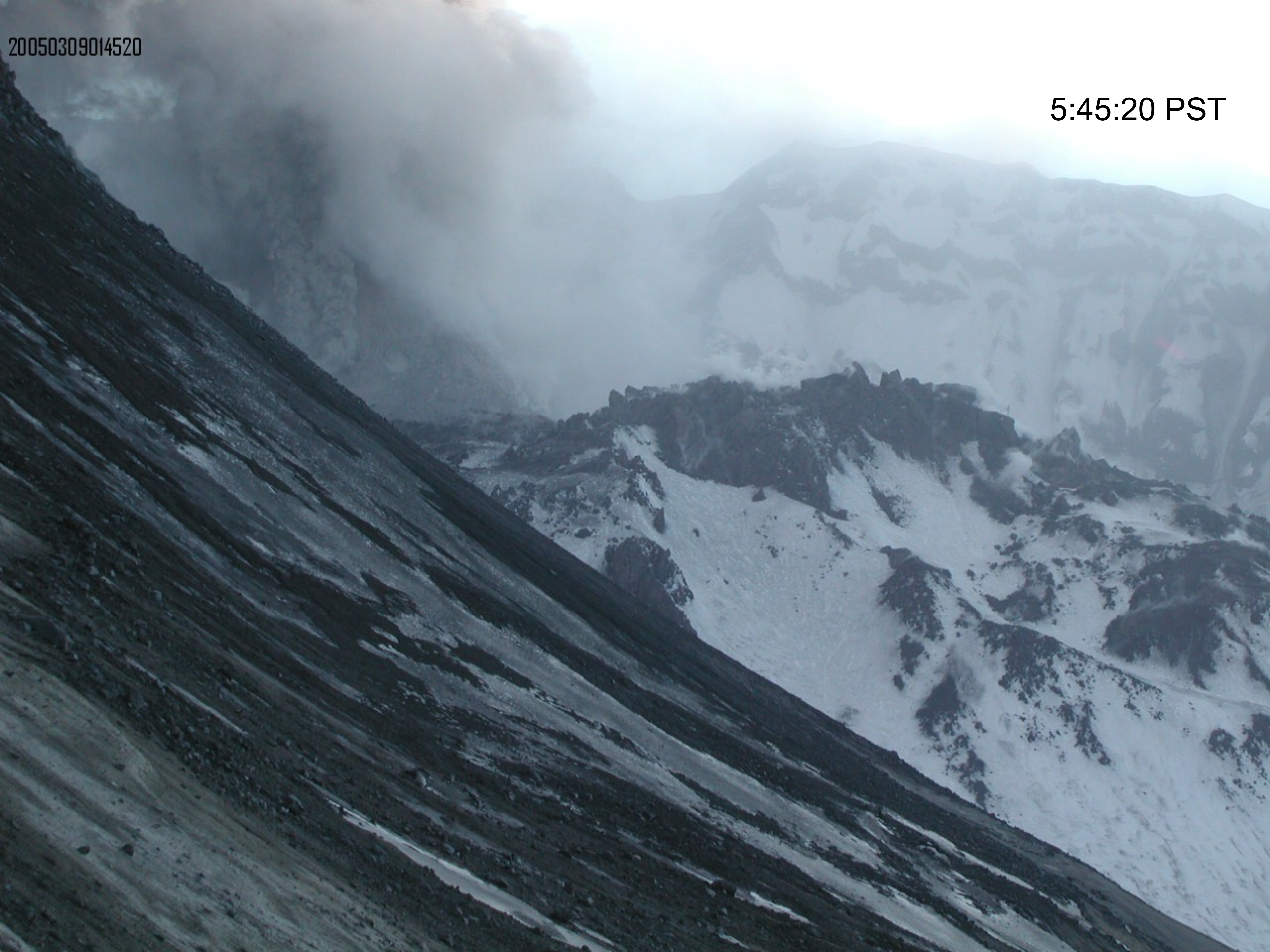
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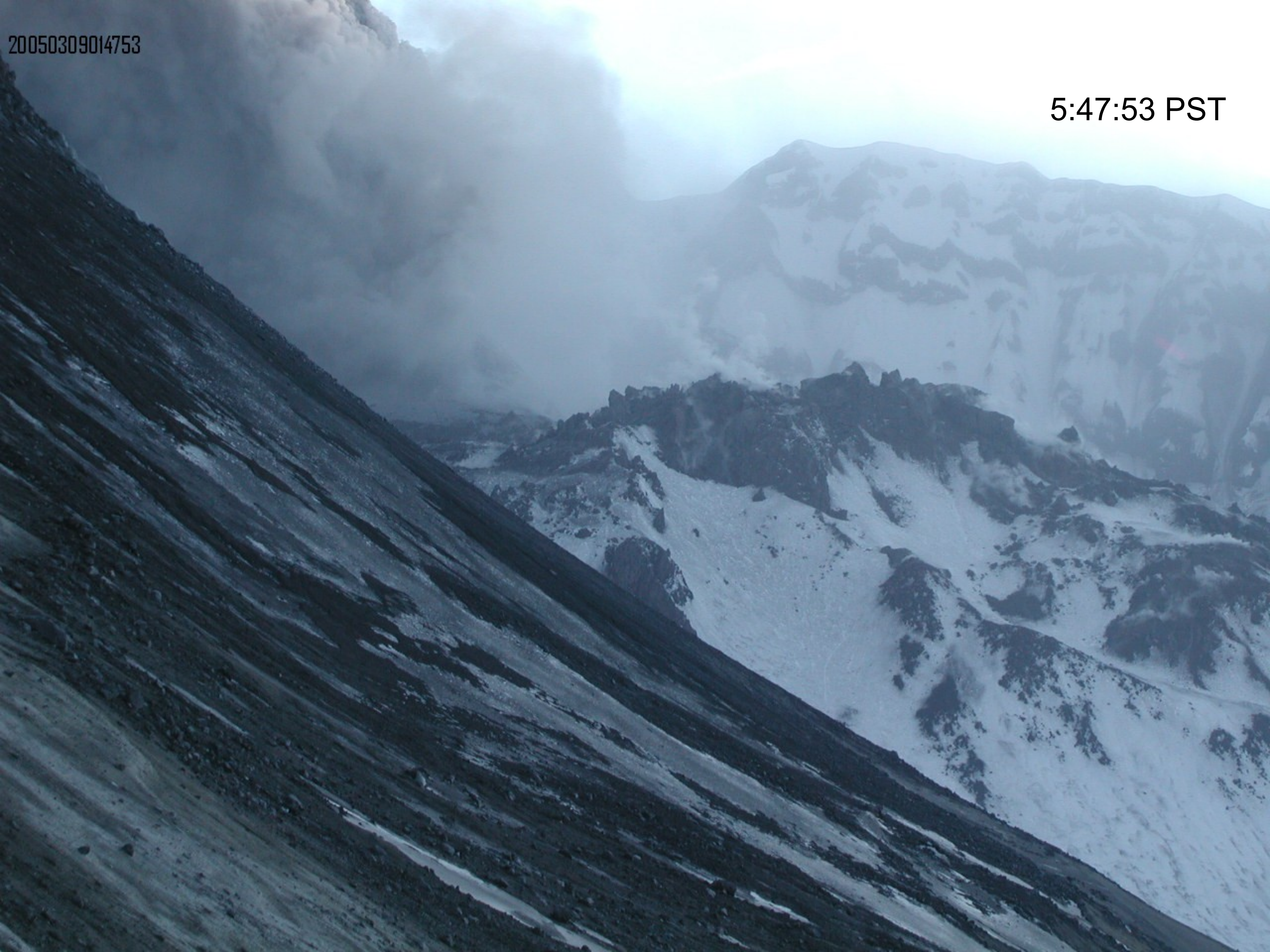
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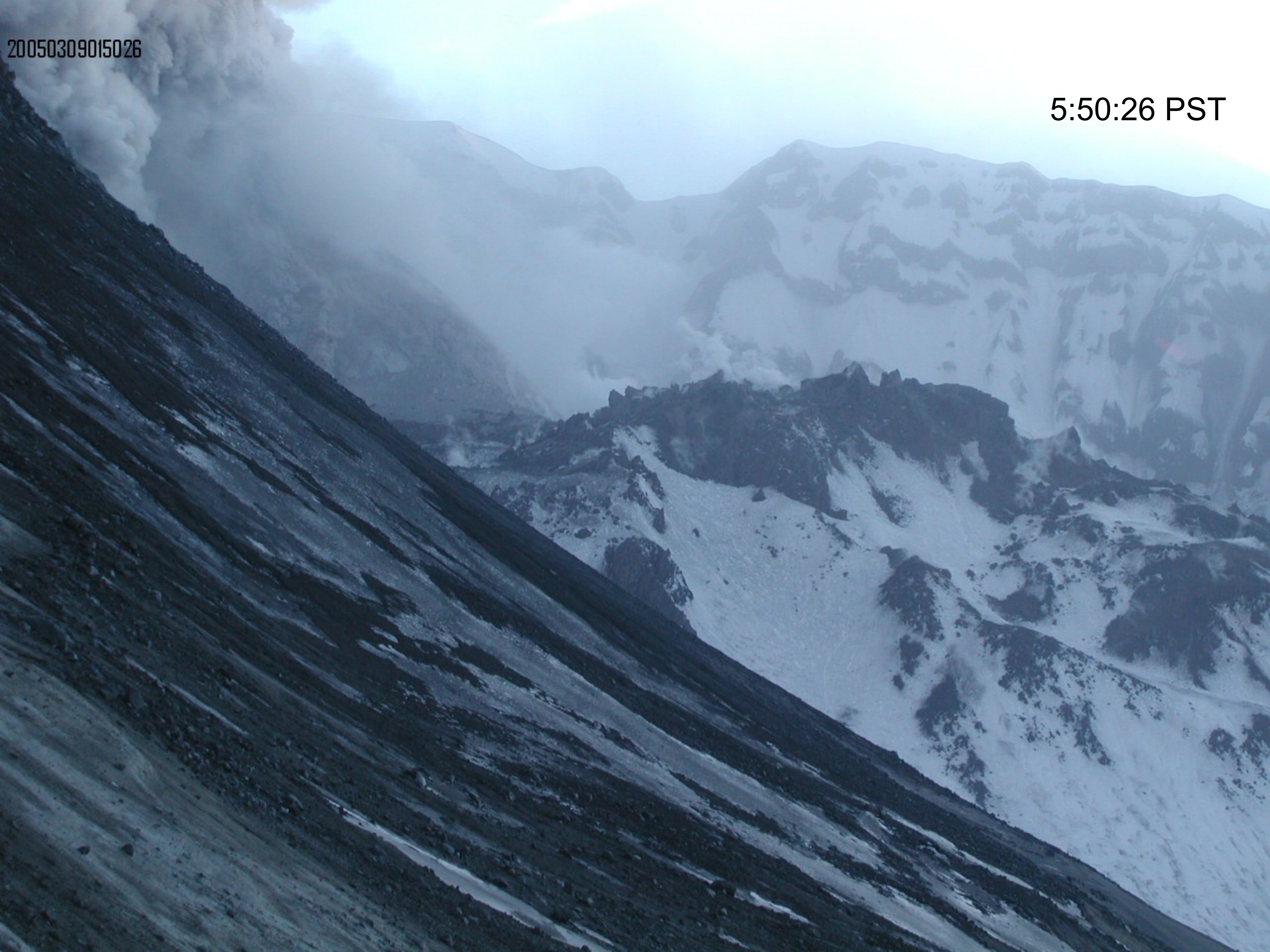
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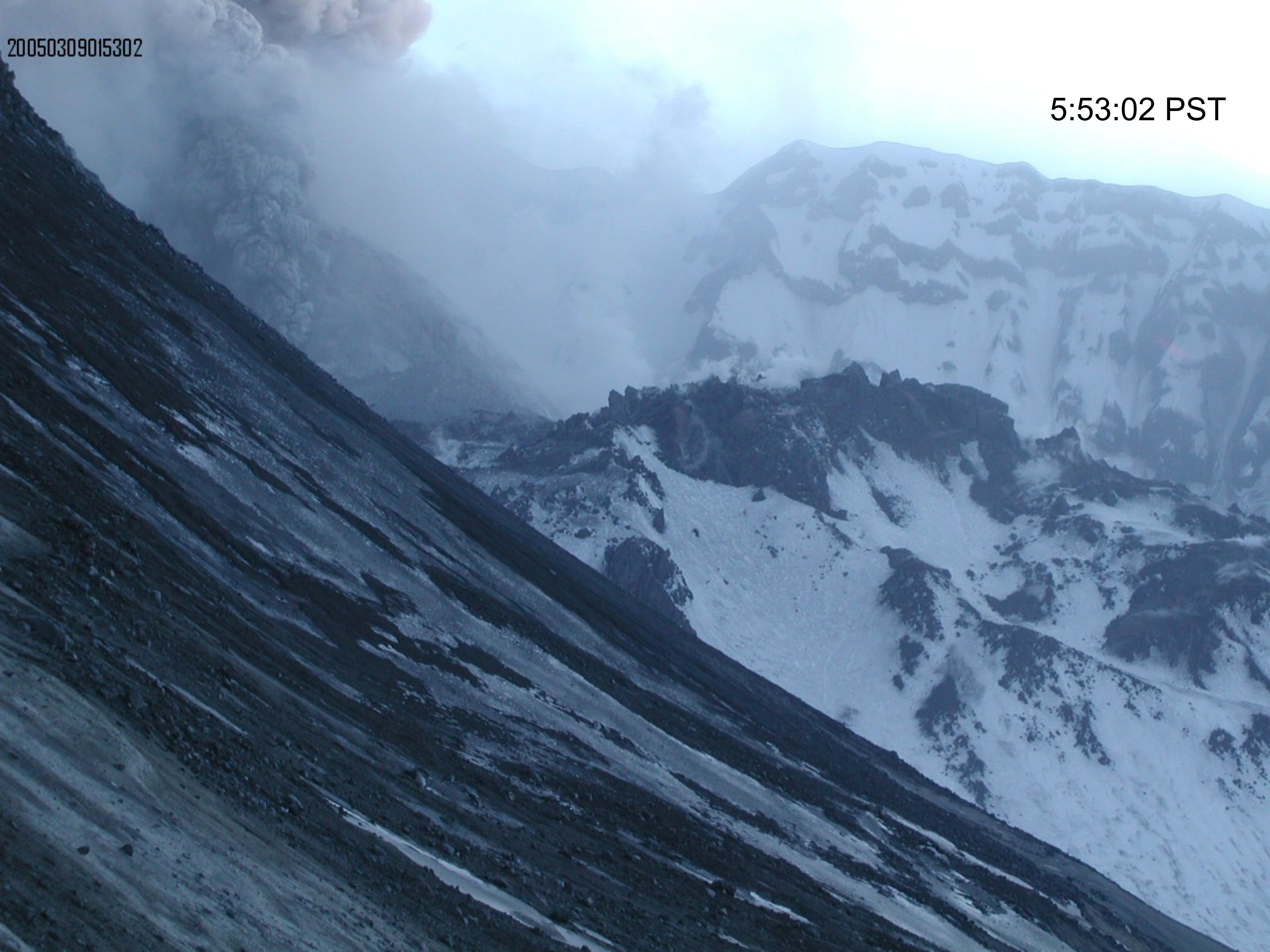
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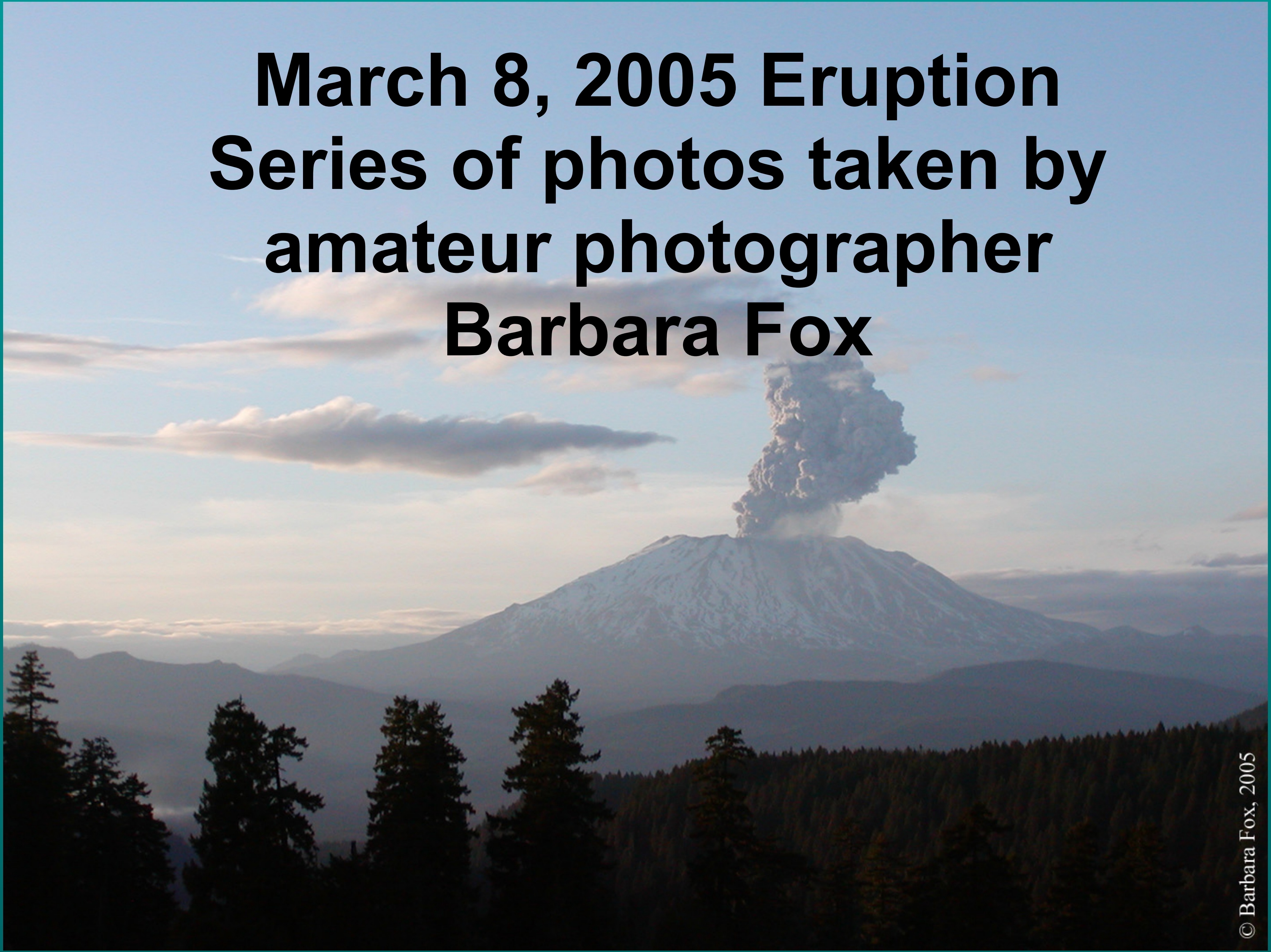
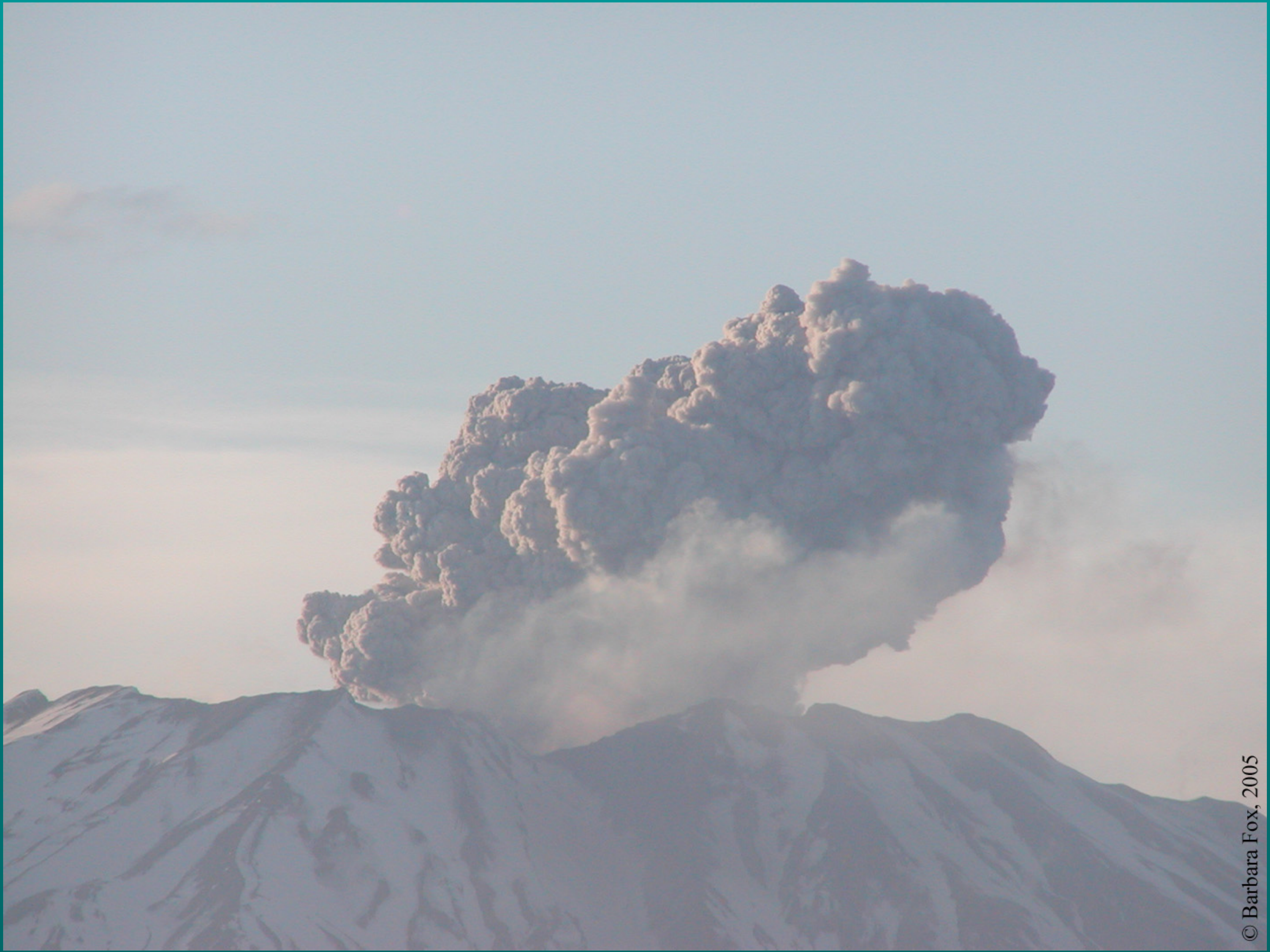
March 8, 2005 Eruption

Series of photos taken by amateur photographer Barbara Fox





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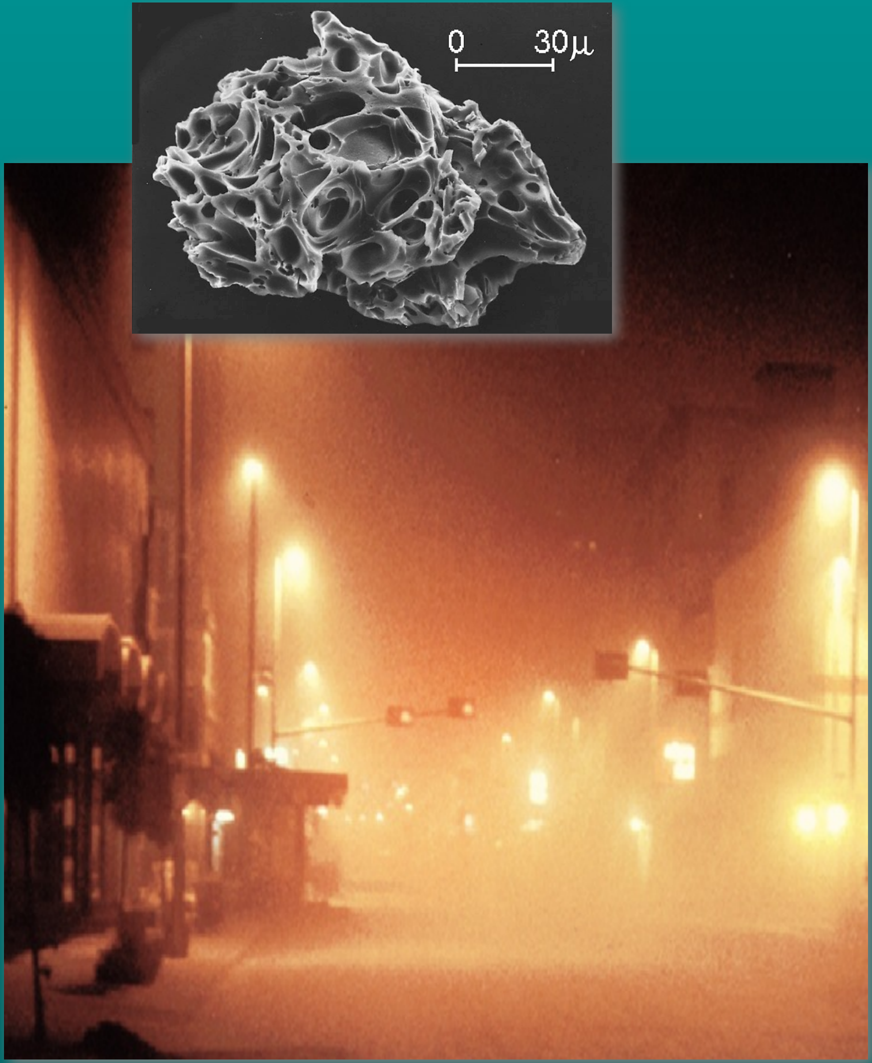
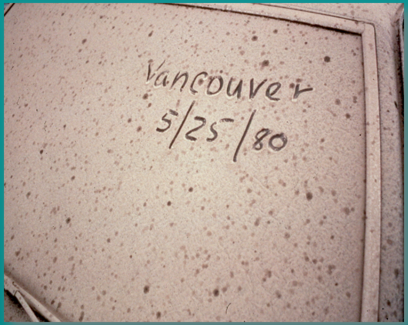
Conclusions and Future Work

- Volcanic Unrest can begin abruptly.
- Mount St. Helens is still erupting!
- Dome building will be punctuated with occasional explosive eruptions of ash and steam with only subtle precursory events.
- Rate of extrusion appears to be constant, despite current low seismicity
- We have a lot of explaining to do!

This is not

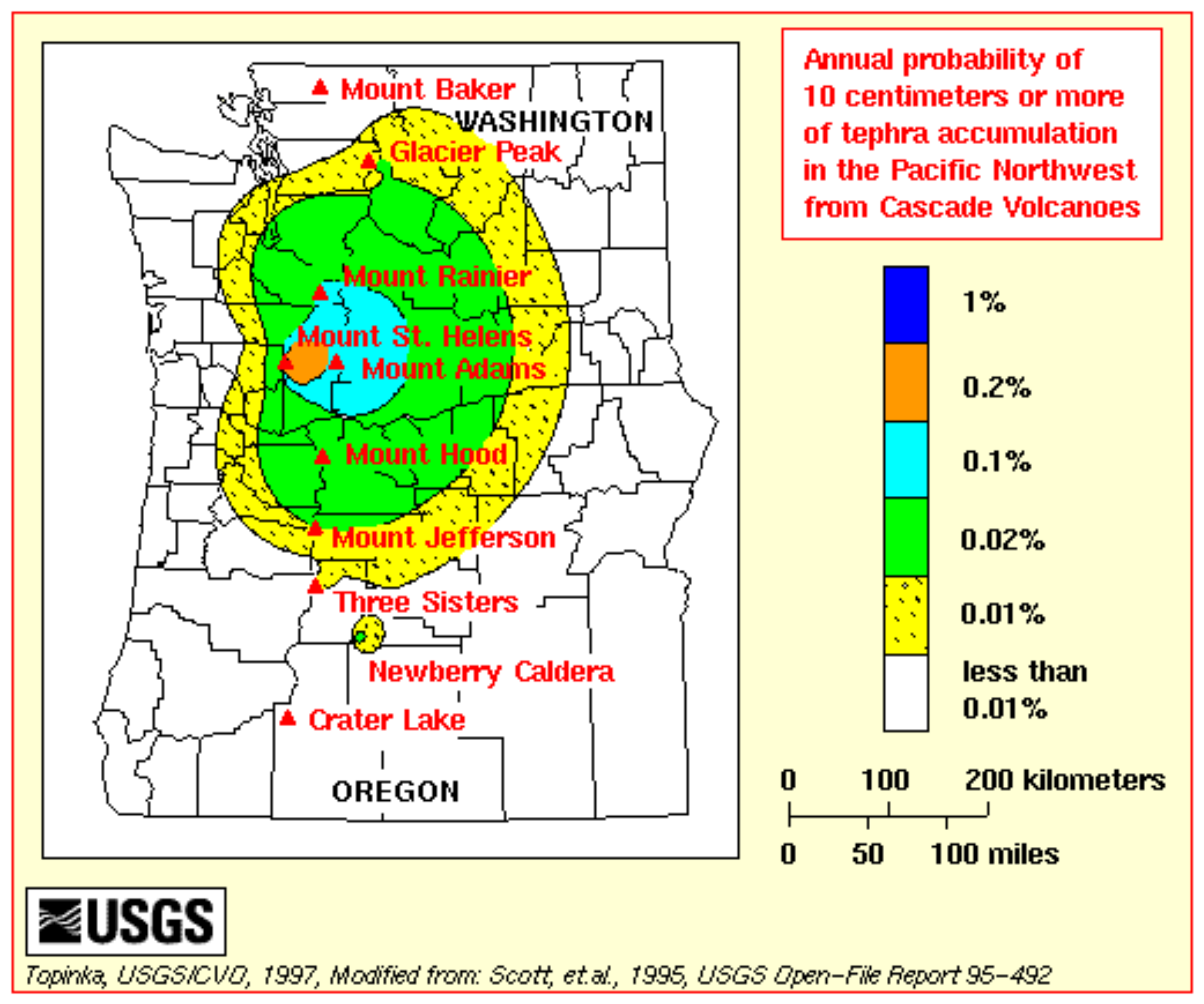
Volcanic Ash





- Particles of shattered rock.
- Falls at normal air temperature at distance from the volcano.
- Non poisonous to touch or breathe.
- Irritates eyes, breathing difficult, reduces visibility, abrasive, clogs filters.
- A hazard to aircraft—even at distance from the volcano

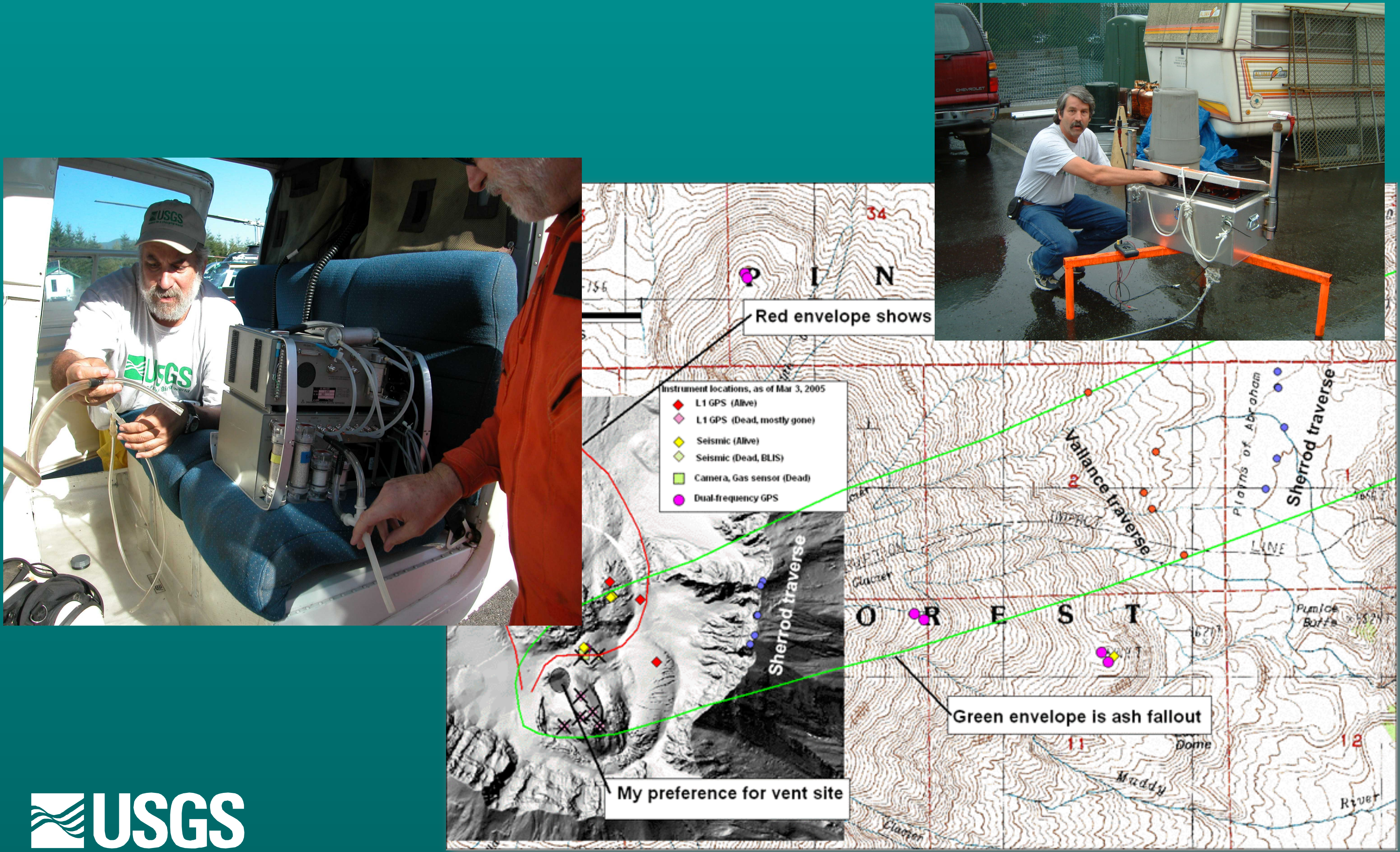
Annual Probability of Volcanic Ash fall in the Pacific Northwest



Annual probability of 10 centimeters or more of tephra accumulation in the Pacific Northwest from Cascade Volcanoes

Topinka, USGS/CVO, 1997, Modified from: Scott, et.al., 1995, USGS Open-File Report 95-492

New technology and methods enhance our ability to monitor volcanoes

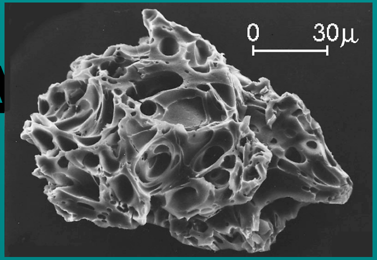


Red envelope shows

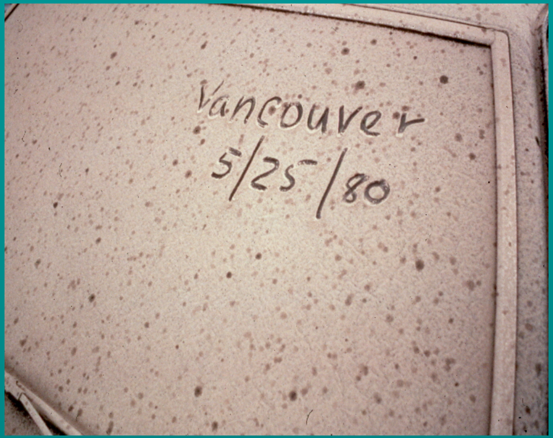
Green envelope is ash fallout

My preference for vent site

Properties of Ash That Can Impact Communications Systems



- Wet Ash is Corrosive; All Ash is A
- Ash hardens when wetted—does
melt away like snow
- Ash gets resuspended by human activity months after an eruption
- Most serious problems result from abrasive and conductive properties of ash



Radio, TV and Telephone Communications…

…are extremely vulnerable to disruption during volcanic ash fall and may fail completely in eruption-effected areas. However, there are many examples of functional communication during ash fall.

Impacts of Volcanic Ash on Communications

- Disruption of signal during eruptions
- Overloading of telephone/computer communication systems.
- Disruption of electrical supplies
- Cooling systems challenged
- Electrical shorting of equipment
- Long-term abrasion of equipment

Examples of Communication System Overloads

- Overloaded Telephone Systems
  - Mount St. Helens 1980
  - Mount Spurr Alaska 1953, 1992
  - Mount Ruapehu NZ 1995-96
- Overloaded Internet Systems
  - Mount Ruapehu NZ 1995-96
  - Nisqually Earthquake 2001

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Examples of Signal Disruptions

- Katmai Alaska 1912—Radio communications inoperative.
- Surtsey, Iceland 1963—Clicks of radio static common.
- Pinatubo, Philippines 1991—Disruption of radio and telephone communications.

Density & load comparison, 10 cm of snow and 10 cm volcanic ash (Johnston, 1997; p. 75)

Density in kg/m3

- New snow 50-700
- Damp new snow 100-2000
- Settled snow 200-3000
- Dry uncompacted ash 500-1,3000
- Wet compacted ash 1,000-2,000

Lava Flows

- Destroy all in their path by burial and fire.
- Melt some snow and ice.
- Collapse on steep slopes and cause Pyroclastic flows

Pyroclastic Flows

- Avalanches of hot gases and rock.
- Form by collapse of lava flows or eruption columns.
- Destroy all in their path by burial, burning and asphyxiation.
- Melt snow and ice and indirectly cause lahars.

USGS

Impact of Lava and Pyroclastic flows on Communications Systems

- Most systems are out of the path of lava and pyroclastic flows.
- Burial and burning of facility.
- Destruction by impact forces.
- Electric Power and water supply may be lost at communication facilities.

Lahars

- Slurries of mud, boulders and water
- Speeds of 40 mph
- Travel to areas distant from the volcano.
- Formed by
  - Landslides
  - Volcanically-melted snow and ice
  - Glacial floods

Impact by Lahars on Communication Systems

- Communication Systems in valleys that head on volcanoes are at greatest risk.
- Loss of electrical power
- Burial of facilities or destruction by impact forces.
- Post-lahar sedimentation blocks river channels causing flooding.

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What You Can Do--

- Learn—Become knowledgeable about volcano issues. Learn whether you live, work or go to school in a volcano hazard zone.

- Inquire---Ask public officials how they advise you to respond.

- Plan---For how you and your family will respond in the event of any natural disaster.

Mitigation Measures
Communication Systems

- Seal facilities including Repeater Stations
  - Shut air intakes
  - Use internal air circulation
  - Seal all equipment that is not already watertight.

Mitigation Measures
Communication Systems

- Remove Ash from external electrical systems and from /insulators/antennae/ microwave dishes.
  - Shut down electrical systems and vacuum, dust, and blow ash from electrical equipment.
  - Replace Teflon with ceramic insulators.
  - Install covers; plastic tarps work well in emergency.

Mitigation Measures
Communication Systems

- Factors affecting electrical flashover
  - Weather conditions (high air moisture co
    increases ash adherence).
  - Presence of electro-static charge.
  - Grain size and ash fall thickness.
  - Soluble components on ash (conductivit
  - Insulator condition and orientation.

Mitigation Measures
Communication Systems

- Further Cleanup
  - Plastic switches abrade quickly; Replace.
  - Clean equipment daily with compressed air or vacuum.
  - Keep moisture out of equipment
  - Increase use of filter paper

Mitigation Measures
Communication Systems

- Practical Advice
- Protect yourself and others.
- Recognize potential for ash fall locally.
- Assemble items required for sealing facilities and for cleaning equipment.
- Maintain backup electrical and communication systems.
- Enjoy the magnificent volcanoes of the Pacific Northwest!

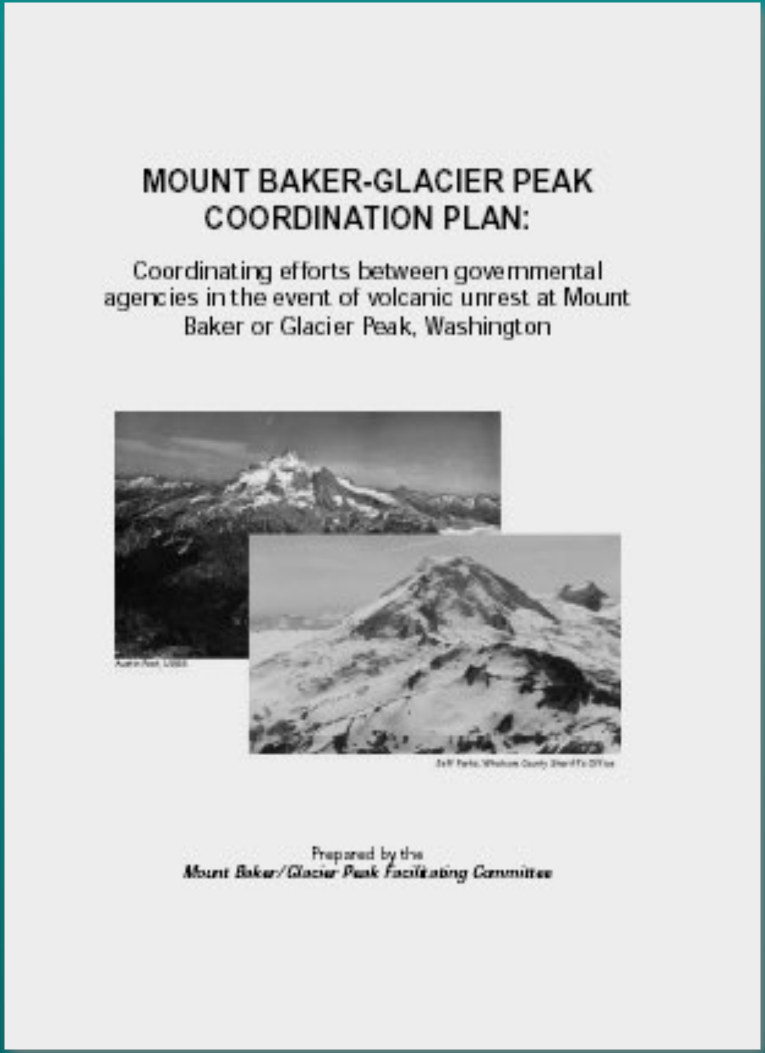
~Conclusions for Communication System Employees~

- Most serious problems result from the conductive and abrasive properties of ash.
- Ash may be resuspended by human activity for months after an eruption.
- Expect disruptions of signals, overloading of telephone/ computer communication systems, and of electrical power, electrical shorting of equipment, abrasion of equipment.
- Most effective measure is to reduce input of ash into systems.
- Lahars pose threat of system burial or flooding.

Get to Know the Volcanic Risk in your Community's Backyard!

Prior planning—Hazard Assessments, Coordination Plans, Practical Exercises

- USGS Volcano Hazards Program develops hazard assessments and works with federal, state and local groups to develop “Hazard Response Plans”.
- Available at Mounts Baker, Rainier, St. Helens, Hood, Glacier Peak and in progress at Central Oregon volcanoes.
- Mount St. Helens plan—updating Hazard Assessments, Coordination Plans, Practical Exercises in progress when volcanic unrest began.



MOUNT BAKER-GLACIER PEAK
COORDINATION PLAN:

Coordinating efforts between governmental agencies in the event of volcanic unrest at Mount Baker or Glacier Peak, Washington

Austin Post, USGS

Jeff Parks, Whatcom County Sheriff's Office

Prepared by the
Mount Baker/Glacier Peak Facilitating Committee

Plan for how you and your community will respond to volcanic unrest.

MOUNT RAINIER
VOLCANO HAZARDS WORKGROUP
A coalition of local, state and Federal agencies dedicated to living responsibly with volcano hazards

USGS

How are officials and scientists responding to the hazard?

- •Mount Rainier Volcano Hazard Work Group formed.
- •Response Plan published.
- •Lahar Detection System installed in Puyallup/Carbon River valleys.
- •Evacuation Plans developed in Pierce Co. and National Park.
- •Long-term Community Outreach in progress.
- •Educator materials developed

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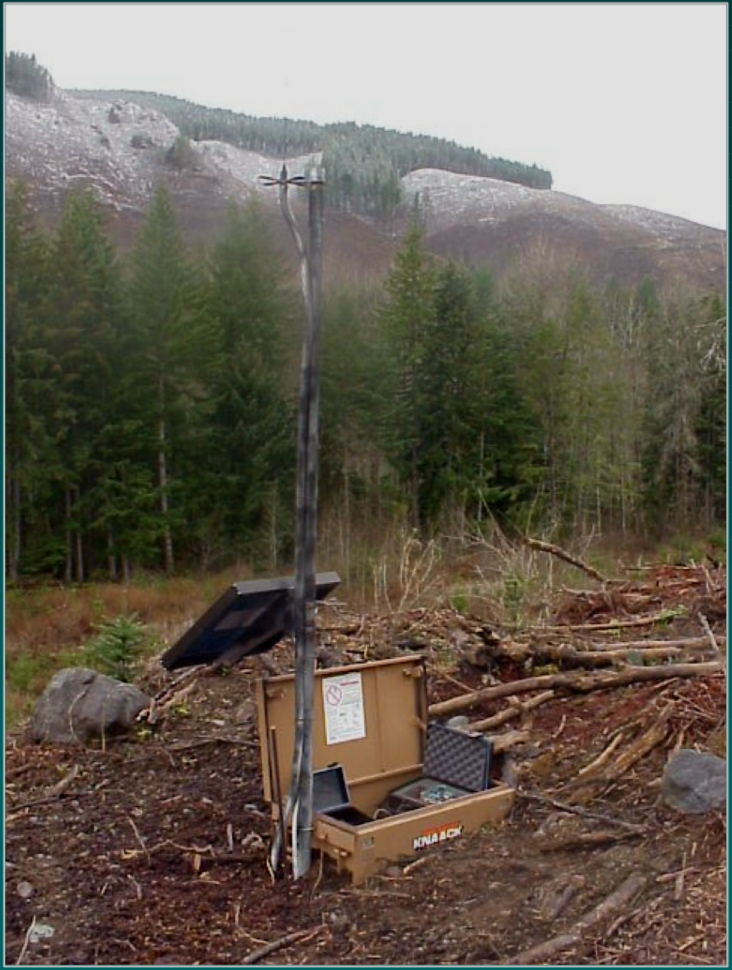
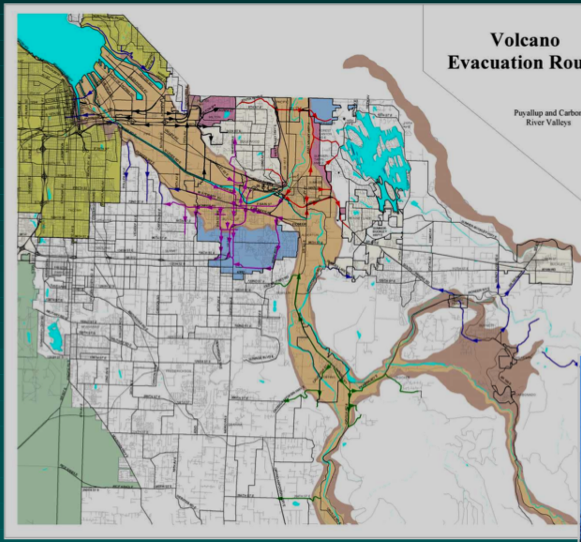
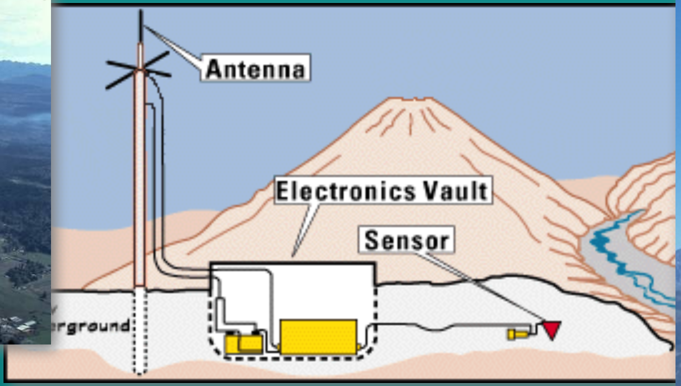
Mount Rainier Lahar-Warning System

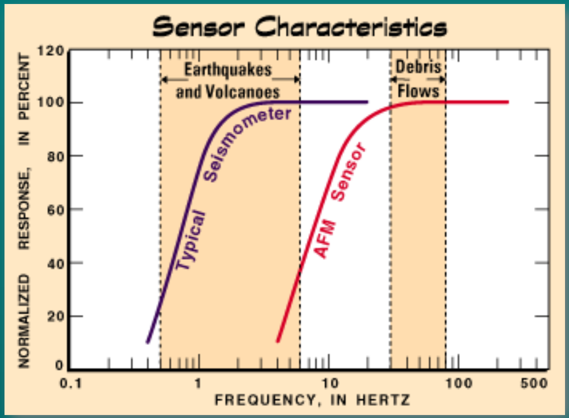
Pierce County, WA, and USGS




Volcano Evacuation Routes
Puyallup and Carbon River Valleys
Evacuation Routes
FIFE
ORTING
PIERCE
PUYALLUP
SUMNER
Volcanic Hazards
Case I - 500 to 1000 yr Frequency
Sub Case of Case I
Case II - 100 to 500 yr Frequency
0
1 Miles
N
Pierce County
Department of Emergency Management

Mount Rainier Lahar Detection and Notification System





MARK TRAIL CHAMPIONS NOAA WEATHER RADIO– THE VOICE OF THE NATIONAL WEATHER SERVICE
NOAA WEATHER RADIOS SHOULD BE AS COMMON IN HOMES AND PUBLIC PLACES AS SMOKE DETECTORS!
NOAA
NOAA Weather Radio

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Volcanoes give us warning signs

- Volcanoes often show signs that they are getting ready to erupt days to months or more in advance.
- Scientists evaluate signs of unrest and look for:
    - Increased emission of volcanic gases
    - Increased earthquake activity
    - Swelling of the volcano.

Celebrate your Community's volcano!

VOLCANIC ASH

...WHAT IT CAN DO AND HOW TO PREVENT DAMAGE

- Visit our websites
  http://volcanoes.usgs.gov
  http://vulcan.wr.usgs.gov

For Ash Information

http://volcanoes.usgs.gov/ash/

Your state and county emergency management websites